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D 828

LIST OF CONTENTS

Page

De Decker, A. H. B.
Near-surface copepod distribution in the south-western Indian and south-eastern Atlantic Ocean. (Published June 1984.) 303

Dingle, R. V.
Mid-Cretaceous Ostracoda from southern Africa and the Falkland Plateau. (Published February 1984.) 97

Gosliner, T. M. *see* Marcus, E. d. B.-R.

Hulley, P. A.
The South African Museum's *Meiring Naude* cruises. Part 14. Family Myctophidae (Osteichthyes, Myctophiformes). (Published February 1984.) 53

Kensley, B.
The South African Museum's *Meiring Naude* cruises. Part 15. Marine Isopoda of the 1977, 1978, 1979 cruises. (Published June 1984.) 213

Marcus, E. d. B.-R. & Gosliner, T. M.
Review of the family Pleurobranchaeidae (Mollusca, Opisthobranchia). (Published February 1984.) 1

Volume 93 is complete in 5 parts.

NEW GENERIC AND SUBGENERIC NAMES PROPOSED IN THIS VOLUME

	Page
Agularcturus Kensley, 1984	217
Hemingwayella (Parahemingwayella) Dingle, 1984	135
Makatinella Dingle, 1984	166
Natalianira Kensley, 1984	279
Pleurobranchaea (Macfarlandaea) Marcus & Gosliner, 1984	40
Pongolacythere Dingle, 1984	148

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ME 93 PART 1 FEBRUARY 1984 ISSN 0303–2515

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(e) *Subject-matter* of the paper, divided into sections to correspond with those given in table of contents
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KOHN, A. J. 1960*b*. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bull. Bingham oceanogr. Coll.* **17** (4): 1–51.
THIELE, J. 1910. Mollusca: B. Polyplacophora, Gastropoda marina, Bivalvia. *In:* SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika* **4**: 269–270. Jena: Fischer. *Denkschr. med.-naturw. Ges. Jena* **16**: 269–270.

(continued inside back cover)

ANNALS OF THE SOUTH AFRICAN MUSEUM
ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

Volume **93** Band
February **1984** Februarie
Part **1** Deel

REVIEW OF THE FAMILY PLEUROBRANCHAEIDAE (MOLLUSCA, OPISTHOBRANCHIA)

By

EVELINE d. B.-R. MARCUS
&
TERRENCE M. GOSLINER

Cape Town Kaapstad

The ANNALS OF THE SOUTH AFRICAN MUSEUM

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Verkrygbaar van die Suid-Afrikaanse Museum, Posbus 61, Kaapstad 8000

OUT OF PRINT/UIT DRUK
1, 2(1–3, 5–8), 3(1–2, 4–5, 8, t.–p.i.), 5(1–3, 5, 7–9),
6(1, t.–p.i.). 7(1–4), 8, 9(1–2, 7), 10(1–3),
11(1–2, 5, 7, t.–p.i.), 15(4–5), 24(2), 27, 31(1–3), 32(5), 33, 36(2), 45(1)

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Kopieregnavrae aan die Suid-Afrikaanse Museum

ISBN 0 86813 054 0

Printed in South Africa by
The Rustica Press, Pty., Ltd.,
Court Road, Wynberg, Cape

In Suid-Afrika gedruk deur
Die Rustica-pers, Edms., Bpk.,
Courtweg, Wynberg, Kaap

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By

Eveline d. B.-R. Marcus
Department of Zoology, University of São Paulo

&

Terrence M. Gosliner*
South African Museum, Cape Town

(With 25 figures)

[*MS accepted 28 June 1983*]

ABSTRACT

A review of the Pleurobranchaeidae is provided, including keys to the notaspidean genera and the described species of Pleurobranchaeidae. Eleven members of the family are considered as junior synonyms while eight additional species are insufficiently described and their status remains uncertain. The morphology of eleven previously described and six new species is characterized and discussed. New taxa are *Pleurobranchaea (Macfarlandaea)* subgen. nov., and *Pleurobranchaea confusa, P. augusta, P. bonnieae, P. bubala, P. notmec*, and *P. vayssierei* spp. nov.

CONTENTS

	PAGE
Introduction	1
General characters of the Pleurobranchaeidae	2
Pleurobranchaea Leue, 1813	8
Pleurobranchaea (Pleurobranchaea) Leue, 1813	8
Pleurobranchaea (Macfarlandaea) subgen. nov.	40
Euselenops Pilsbry, 1896	42
Pleurobranchella Thiele, 1925	43
Koonsia Verrill, 1882	46
Gigantonotum Lin Guangyu & Tchang Si, 1965	48
Zoogeography of the Pleurobranchaeidae	48
Acknowledgements	49
References	49

INTRODUCTION

This paper was originally intended to be the eighth contribution to the catalogue of the western Atlantic warm-water Opisthobranchia (Marcus, Ev. 1972*a*, 1972*b*, 1973, 1974, 1978, 1980, 1982*a*). During the course of investigations it was

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Ann. S. Afr. Mus. **93** (1), 1984: 1–52, 25 figs.

determined that the family Pleurobranchaeidae was in need of substantial revision and the scope of this work was expanded.

The classification of the Pleurobranchaeidae has in many cases been based upon insufficiently described material, and the species were often simply identified with previous descriptions from geographically related regions. Vayssière (1885: 108) found that the descriptions and diagnoses of the Pleurobranchacea had been so incomplete that the species were confused, considered as synonyms, or recorded only as varieties. He tried to define clearly the important characters.

The external morphology is influenced by preservation, contraction, and loss of pigment. The presence of well-separated rhinophores serves as a familial distinction.

The jaw plates and radula can be used for generic separation but hardly differ within a genus. Vayssière (1901: 72) maintained that jaws and radula are indispensable for classification. He stated that it was a pity that Bergh had not figured jaws and radula, as the comparison of these organs might have eliminated all doubts (Vayssière 1901: 51, 71).

Few authors have described the reproductive organs completely, although these offer good specific characters (Vayssière 1901: 53). This is probably largely due to the fact that the reproductive organs are very difficult to dissect without tearing the various ducts, as indicated by Vayssière (1901: 38). For this study there are sufficient specimens of some species, but in the case of several others complete descriptions cannot be given nor can all specimens be classified. Often the male organs have not been observed in detail and they are often species-specific in their structure. For these reasons the present authors have concentrated on the determination of penial morphology but describe other characters whenever possible.

Vayssière (1898: 234) described the oviduct entering the albumen gland in the Berthellinae: *Berthellina brocki* (fig. 180) and *Berthella ocellata* (fig. 182). In *Berthellina edwardsi* (fig. 179) the duct, though touching the albumen gland, seems to continue (p. 234) to its own outer opening. Vayssière stated that in the Pleurobranchidae, *Pleurobranchus* (figs 177–178), *Susania*, and *Oscanius*, and in the Pleurobranchaeidae there is no such connection; the oviduct goes directly into the vagina and the gland mass opens into the outer part of the vagina. In earlier papers the senior author also misinterpreted the close proximity of the oviduct to the gland mass as an entrance in *Pleurobranchus aerolatus* (Marcus, Ev. & Marcus 1967*a*: 165, fig. 19, o), *Pleurobranchaea gela* (Marcus, Ev. & Marcus 1966: 176, fig. 37, oi), and *P. agassizii* (Marcus, Ev. & Marcus 1967*a*: 49, fig. 56D, ov).

GENERAL CHARACTERS OF THE PLEUROBRANCHAEIDAE

The colours are variable in life, but most species are brownish. A shell is absent. The size differs between species but depends on age and may vary between populations. The notum varies in size. It is usually slightly smaller than or equal to the foot in size, but sometimes it is larger. The relative proportions of the mantle to the foot were used for generic separation but they are largely dependent upon the degree of contraction during preservation. Anteriorly the notum is separated from the oral veil by a slight fold. The notum may be smooth or rough, or with bosses or tubercles, which may be altered during preservation.

The right side of the notum projects over the gill, forming an exhalant siphon posteriorly. On the left side the notum sometimes leaves the upper side of the foot free. Posteriorly it merges gradually with the upper side of the foot. In *Pleurobranchaea brockii* the notum and foot remain separated posteriorly.

The oral veil is broad. Its anterior border bears one or two rows of simple or branched papillae, which may disappear with fixation. The sides of the veil form the oral tentacles, which are split posteriorly and inwardly rolled. The blunt, rolled rhinophores are situated in the angles between the tentacles and lateral notal borders and are well separated from each other.

Between the right rhinophore and the gill are the genital apertures, surrounded by a circular fold. This fold often has one or two flaps that are frequently protruded. The flaps vary intraspecifically. Behind these apertures lies the prebranchial gland, Bourne's gland, called the organ of Bojanus by Moquin-Tandon (1870: 20). It opens on a small papilla.

The gill occupies the middle of the right side below the border of the notum. It has a variable number of pinnae on both sides, which increases with age. The gill rachis is smooth or bears two rows of papillae, which may disappear with preservation. Part of the underside of the gill is adnate to the body wall. The anal opening is situated between the gill and notum, while the nephropore is ventral to the gill.

The anterior border of the foot is transversely grooved. The hind end is rounded and often bears a soft spur or horn on the dorsal side. The presence or absence of the spur (Figs 6A, 13A) varies intraspecifically. The pedal (metapodial) gland on the ventral side of the foot is not always visible. Macnae (1962: 168–169) found this gland only in sexually active individuals, although its absence may be a result of poor preservation.

The mouth opening is often extended by the everted buccal cavity and protruded pharynx. The pharynx has a vertical entrance to the digestive tract and is flanked by the jaw plates. The anterior border of the jaws may vary in shape (Figs 6G, 19C) even in the same species (Marcus, Ev. & Marcus 1966, fig. 35). The platelets comprising the jaws are polygonal columns with a flat surface. The ratio of length to breadth of the platelets varies intraspecifically and may vary with position in a single individual (Fig. 10C–F). We agree with O'Donoghue (1929: 58) that the jaw platelets cannot be utilized for specific separation.

The radula has numerous transverse rows of uncinate, uni- or bicuspid teeth. A rachidian tooth is rarely present. The teeth are largest in the middle of the half-row. The presence or absence of a secondary denticle on the teeth is variable. The number of unicuspid teeth on the outer edge of the radula also varies. In some specimens of *P. tarda* there are up to twenty unicuspid teeth, while in other individuals they are entirely absent. We believe that the rudimentary secondary cusp on all teeth in *P. californica* is a useful subgeneric character. In specimens where the radular rachis is more or less complete, the first lateral tooth varies in size in different rows. It gradually increases in size from older teeth to newer and ranges from 0,105 to 0,250 mm. As additional teeth are added to the radula from the inner side, the size of the inner lateral again decreases. Malformations of teeth are not rare. Most commonly two adjacent teeth are fused within a transverse row. On one occasion two entire transverse rows of abnormal teeth were observed (Fig. 13B).

The stomach often contains the remains of food, demonstrating the variability of diet within the Pleurobranchaeidae. In the specimens examined, prey included the bryozoan *Cellaria* sp., polychaetes up to 15 mm long, an amphipod, a small prosobranch shell, a specimen and a pharynx of a pleurobranchid, a gymnosomatid radula, an aeolid 2,5 mm long and a complete pharynx with jaw plates and radula, a 20 mm branch of a crinoid, a spine of the sea urchin *Eucidaris tubulinoides* (identified by F. M. Bayer, U.S. National Museum) and a 6 mm long octopod. A 65 mm specimen of *Pleurobranchaea brockii* contained four specimens of *Philine aperta* in its stomach, the largest of which was 18 mm in length. Eales (1937) found fourteen specimens (10–17 mm long) of *Pleurobranchaea tarda* in the stomach of *Pleurobranchella nicobarica*.

Bergh (1897: 2) indicated that a blood gland is situated dorsal to the heart in the Pleurobranchacea, not over the central nervous system as in the Doridacea.

Bergh's (1897: 25–26, pl. 4 (figs 1–7)) description and figures of the cuticular penial tube of *P. meckelii* differ from Vayssière's (1901: 40–41, fig. 228). As this is the evaginable part of the male duct, we consider it as the penis proper. Bergh's (1897: 34–37) terms for the reproductive ducts differ somewhat from ours. Vayssière (1901: 39–40, pls 4–6) described the male duct of *P. meckelii*. He called Bergh's term 'penial sheath' the penial sac (his fig. 224) and applied the term 'penis' rather than 'glans penis' to the small muscular cone at the opening of the efferent duct into the atrium (his figs 225–226). He did not mention nor figure any cuticularized penis inside the efferent duct, except for a transverse section (fig. 228). Macnae (1962) roughly figured the penis of four pleurobranchid species. MacFarland (1966: 99, pl. 17 (figs 1–7)) described and figured the 'glans penis' of *Pleurobranchaea californica* and compared it with Bergh's description of *P. meckelii*.

The inner genital organs dissected from the intestine and digestive gland, but still connected with the body wall, can best be studied by slightly staining them in carmine and sketching them before clarification to see the cuticular penis, if present. In laying the organs flat (Vayssière 1901: 38) for balsam preparations they frequently stick together or tear, so that the course of the ducts is no longer recognizable.

From the ovotestis, in which the follicles contain either sperm or oocytes (Mazzarelli 1891: 234), a winding hermaphroditic duct emerges. It widens as an elongate ampulla. Shortly after it narrows again, it divides into the oviduct and male duct.

The ciliated oviduct widens, forming some pouches full of sperm, the spermatocyst (Fig. 3B, y). The following long, coiled portion is also ciliated. The oviduct enters the vagina near the stalk of the vesicular spermatheca. The albumen and mucous glands open into the vagina.

The male duct generally enters the centre of a round prostatic gland composed of many narrow tubules. It emerges from the gland on the opposite side and enters the penial sac, when present, usually near its fundus and often close to the retractor muscle. In *Euselenops* the prostatic cells are contained with the efferent duct.

The penial sac is narrow along the loop of the efferent duct in *P. tarda* and slightly wider in *P. maculata, P. bubala*, and *P. californica*, and widest in *P. meckelii* and *P. augusta*. In one specimen of *P. notmec* and in *P. bonnieae* and *P. inconspicua*, it is tight around the many windings of the efferent duct (Fig. 18F). The number of crowded windings of the efferent duct in the penial sac in *P. inconspicua, P. bonnieae* and *P. notmec* could not always be accurately determined. The penis is not known in detail for *P. maculata*. The penis does not have a cuticle in *P. agassizii, P. brockii, P. bonnieae*, and *P. vayssierei*. It is covered with papillae in *Euselenops luniceps*, and with cuticular hooks in *Pleurobranchella nicobarica* (Fig. 24D) and *Koonsia obesa*. There is an external cuticle in *Pleurobranchaea notmec* (Fig. 18C–E), and an internal cuticular cylindrical stylet of different transverse section (Fig. 1A–H) in *Pleurobranchaea meckelii, P. tarda, P. inconspicua, P. californica*, and *P. bubala*.

The spermatocyst is often a simple widening, or its epithelium forms pouches. In *P. brockii* it is generally a spiral caecum of three to five whorls, but in one specimen (SAM–A29866) it consisted of epithelial pouches.

The spermatheca is small and not transparent, or wide and thin-walled. In *P. bubala* there may be a larger ental vesicle with a smaller ectal one on its top (Fig. 16G).

Mazzarelli (1891: 233–238, figs 1–3) gave an excellent description of the reproductive apparatus of *P. meckelii*, but seemed to have confused the prostate and albumen glands. He described the cuticular tube in the efferent duct, though he called it a filament. By dissecting mating specimens he found that the cuticular tube is projected from the everted penial sheath into the widenings of the inner oviduct of the partner, the spermatheca and spermatocyst.

KEY TO THE NOTASPIDEAN GENERA

1	Shell external	2
—	Shell internal or absent	5
2	Shell partly covered by mantle	*Gymnotoplax*
—	Shell not covered by mantle (Umbraculacea)	3
3	Gill from left rhinophore along front and most of right side	*Umbraculum*
—	Gill only on part of the right side	4
4	Rachidian tooth present	*Tylodina*
—	No rachidian tooth	*Roya*

5 Shell internal; rhinophores anteromedial, posterior to veil; jaw elements flat posteriorly, pointed anteriorly (Pleurobranchidae) 6

— Shell absent, rhinophores lateral, between veil and mantle border; jaw elements more or less high polygonal column (Pleurobranchaeidae) 11

6 Oviduct enters albumen gland (Berthellinae) 7

— Oviduct unites with vagina (Pleurobranchinae) 9

7 Teeth lamelliform 8

— Teeth hook shaped . . . . *Berthella*

8 Teeth with one secondary cusp; prostatic gland cells in male duct . . . . *Pleurehdera*

— Teeth denticulate; prostate present . . . . *Berthellina*

9 Prostate present 10

— Prostatic gland cells in male duct . . . . *Susania*

10 Shell large; big flaps around genital apertures . . . . *Oscanius*

— Shell small, no big flaps around genital apertures . . . . *Pleurobranchus*

11 Notum half the length of foot 12

— Notum larger than foot or equal 13

12 Fold on hind end of notum, penis papillate . . . . *Euselenops*

— Spur on hind end of foot, penis with hooks . . . . *Koonsia*

13 Radular teeth unicuspid . . . . *Pleurobranchella*

— Radular teeth bicuspid 14

14 Secondary cusp of tooth well developed . . . . *Pleurobranchaea (Pleurobranchaea)*

— Secondary cusp rudimentary . . . . *Pleurobranchaea (Macfarlandaea)*

SPECIES OF THE FAMILY PLEUROBRANCHAEIDAE TREATED IN THE PRESENT PAPER

Pleurobranchaea meckelii Leue, 1813; Mediterranean to Gulf of Guinea
P. maculata (Quoy & Gaimard, 1832); Australia, New Zealand, Japan
P. tarda Verrill, 1882: 546; western and south-eastern Atlantic
P. agassizii Bergh, 1897; western Atlantic
P. brockii Bergh, 1897: 41; Japan to South Africa
P. inconspicua Bergh, 1897: 49; western Atlantic, Mediterranean, Israel
P. confusa sp. nov. *pro parte Koonsia obesa*, Verrill; north-western Atlantic
P. augusta sp. nov.; west Africa
P. bonnieae sp. nov.; Florida
P. bubala sp. nov.; South Africa
P. notmec sp. nov.; Israel
P. vayssierei sp. nov.; Algiers
P. (Macfarlandaea) subgen. nov.
P. (M.) californica MacFarland, 1966: 94; California
Euselenops luniceps (Cuvier, 1817); Japan to South Africa
Koonsia obesa Verrill, 1882: 545; 1884, pl. 28 (fig. 7); western Atlantic
Pleurobranchella nicobarica Thiele, 1925: 283; Indian Ocean, South Africa
Gigantonotum album Lin Guangyu & Tchang Si, 1965; China

LIST OF SYNONYMS

Pleurobranchaea meckelii var. *occidentalis* Bergh, 1897: 28; *syn. nov.* of *P. tarda*
Pleurobranchaea hedgpethi Abbott, 1952; *syn. nov.* of *P. inconspicua*
Oscaniopsis semperi Bergh, 1897: 54; syn. of *Euselenops luniceps*
Oscaniopsis compta Bergh, 1897: 58; syn. of *Euselenops luniceps*
Oscaniopsis amboinei Vayssière, 1901: 15; syn. of *Euselonops luniceps*

Pleurobranchaea capensis, Vayssière, 1901: 46; *syn. nov.* of *P. tarda*
Pleurobranchoides gilchristi O'Donoghue, 1929: 62; *syn. nov.* of *Pleurobranchella nicobarica* Thiele
Pleurobranchaea hamwa Marcus & Marcus, 1955: 21; syn. of *P. inconspicua*
Pleurobranchaea gemini Macnae, 1962: 178; *syn. nov.* of *P. brockii*
Pleurobranchaea gela Marcus & Marcus, 1966: 174; *syn. nov.* of *P. inconspicua*
Pleurobranchaea occidentalis Bergh, 1897: 28; *syn. nov.* of *P. tarda*
Pleurobranchaea novaezealandiae Cheeseman, 1878: 378; syn. of *P. maculata*

INSUFFICIENTLY DESCRIBED SPECIES NOT TREATED HERE

Pleurobranchillus morosus Bergh, 1892: 28
Pleurobranchaea morula Bergh, 1905: 48
Pleurobranchaea melanopus Bergh, 1907: 33
Oscaniopsis pleurobranchaeana Bergh, 1907: 35
Pleurobranchaea algoensis Thiele, 1925: 282
Pleurobranchaea japonica Thiele, 1925: 283
Pleurobranchaea dorsalis Allan, 1933: 445

Classification, synonymy, and geographic distribution of the insufficiently described species remain doubtful, particularly as two or more well-distinguished species may be sympatric.

KEY TO THE SPECIES OF THE FAMILY PLEUROBRANCHAEIDAE

1	Notum half the length of the foot	2
—	Notum larger than foot or equal	3
2	Fold on hind end of notum, penis papillate	*Euselenops luniceps*
—	Spur on hind end of foot, penis with hooks	*Koonsia obesa*
3	Radular teeth unicuspid	*Pleurobranchella nicobarica*
—	Radular teeth bicuspid	4
4	Secondary cusp of tooth well developed	*Pleurobranchaea (Pleurobranchaea)* 5
—	Secondary cusp rudimentary	*Pleurobranchaea (Macfarlandaea) californica*
5	Penis soft, cuticle absent	6
—	Penis cuticular	11
6	Vagina short	7
—	Vagina long	10
7	No penial sac	*P. agassizii*
—	Penial sac developed	8
8	Penial sac narrow	*P. maculata*
—	Penial sac globular	9
9	Root of penis enlarged	*P. bonnieae*
—	Root of penis not wider than following part	*P. vayssierei*
10	Penis very long and thick	*P. brockii*
—	Penis short	*P. confusa*
11	Penis a slightly curved stylet	12
—	Penis a long tube with many loops in penial sac	13
12	Penial sac narrow, tubular	*P. tarda*
—	Penial sac widened around duct	*P. bubala*
13	Vagina short	14
—	Vagina long	*P. meckelii*
14	Penial cuticle with crest, less than ten loops in penial sac	*P. augusta*
—	Penial cuticle cylindrical, ovoid in transverse section, up to twenty loops in penial sac	*P. inconspicua*

Remarks

Sufficient characters were not obtained to include *P. notmec* sp. nov. in the key, though in the discussion it is distinguished from similar species. Bergh's (1892: 27, 28) genus *Pleurobranchillus* for *morosus* and *brockii* was synonymized to *Koonsia* by Pilsbry (1896: 221, 223) and by Abbott (1974: 349). Later Bergh (1897: 27, 28) transferred *morosus* and *brockii* to *Pleurobranchaea*.

Thiele's (1925: 283) *Pleurobranchella* and its synonym *Pleurobranchoides* O'Donoghue, 1929, have a notum noticeably larger than the foot. This is exceptional in the family Pleurobranchaeidae.

Pleurobranchaea Leue, 1813

Pleurobranchidium Blainville, 1824.
Cyanogaster Blainville, 1825.
Pleurobranchillus Bergh, 1892.
Koonsia Verrill, 1882, partim.
Non Pleurobranchella Thiele, 1925.

Type species

Pleurobranchaea meckelii Leue, 1813.

Diagnosis

Pleurobranchaeidae with bicuspid radular teeth.

Pleurobranchaea (Pleurobranchaea) Leue, 1813

Type species

Pleurobranchaea meckelii Leue, 1813.

Diagnosis

Secondary cusp of radular teeth well developed.

Remarks

Thiele's (1931: 419) definition is confused and the forms he attributed to the subgenus have quite different characters.

Pleurobranchaea meckelii Leue, 1813

Figs 1A, H–P, 2A–C

Pleurobranchaea meckelii Leue, 1813.
Pleurobranchidium meckelii Blainville, 1824.
Pleurobranchaea meckelii Leue, 1813. Mazarelli, 1891: 223. Pelseneer, 1894: 31, figs 86–99. Bergh, 1897: 7, pls 1–4, pl. 7 (figs 16–18); 1899: 26; 1902: 228, pl. 9 (figs 1–3). Vayssière, 1901: 42, figs 205–231.
Non P. meckelii var. *occidentalis* Bergh, 1897: 28 (= *P. tarda*).

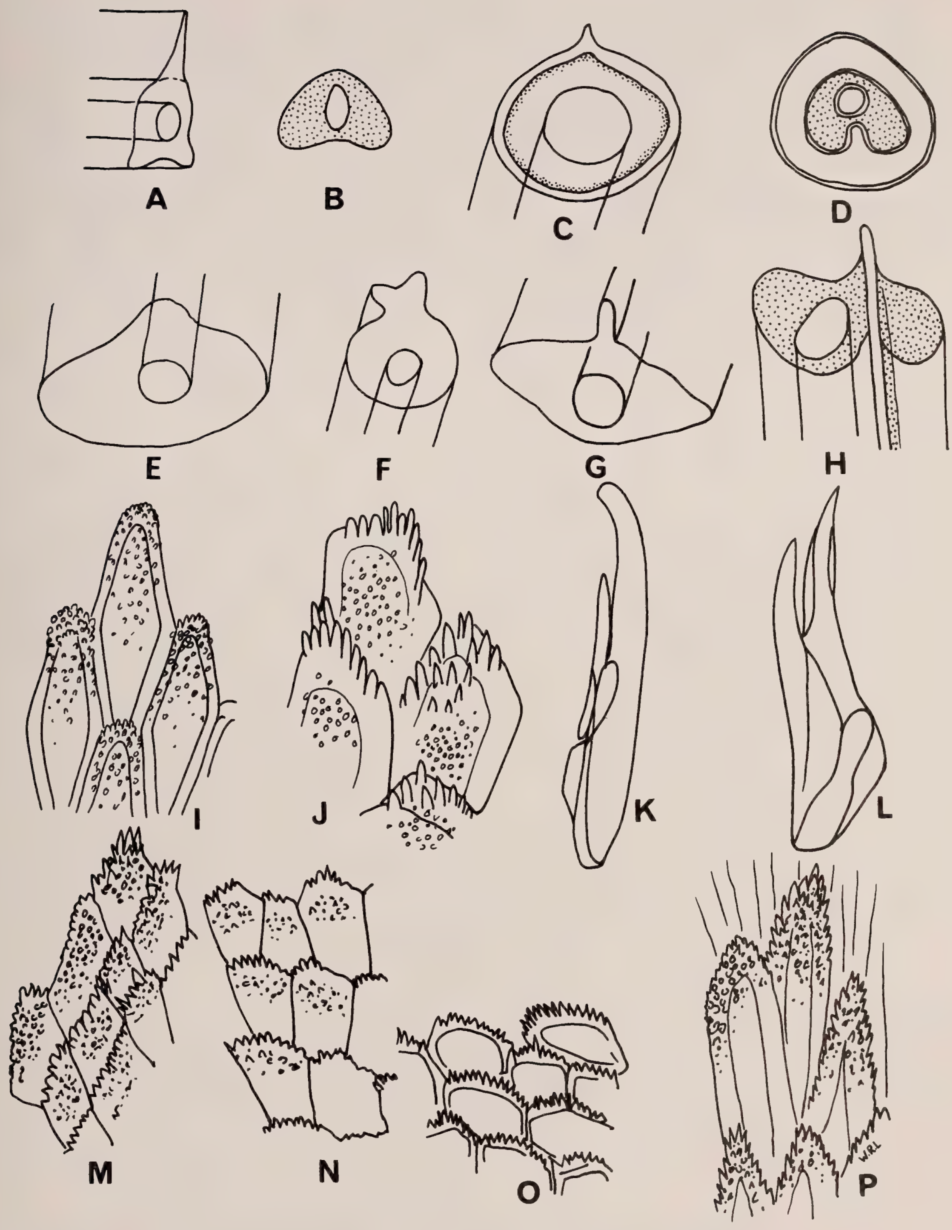

Fig. 1. A–H. Optical transverse sections of penial stylets. A, H. *Pleurobranchaea meckelii* Leue, 1813. B. *P. inconspicua* Bergh, 1897. C. *P. augusta* sp. nov. D. *P. bonnieae* sp. nov. E–G. *P. notmec* sp. nov. I–P. *P. meckelii* Leue, 1813. I–J. Jaw platelets from Algiers specimen from Vayssière's collection. K–L. Teeth from Algiers specimen. M–P. Jaw platelets from Israel specimen.

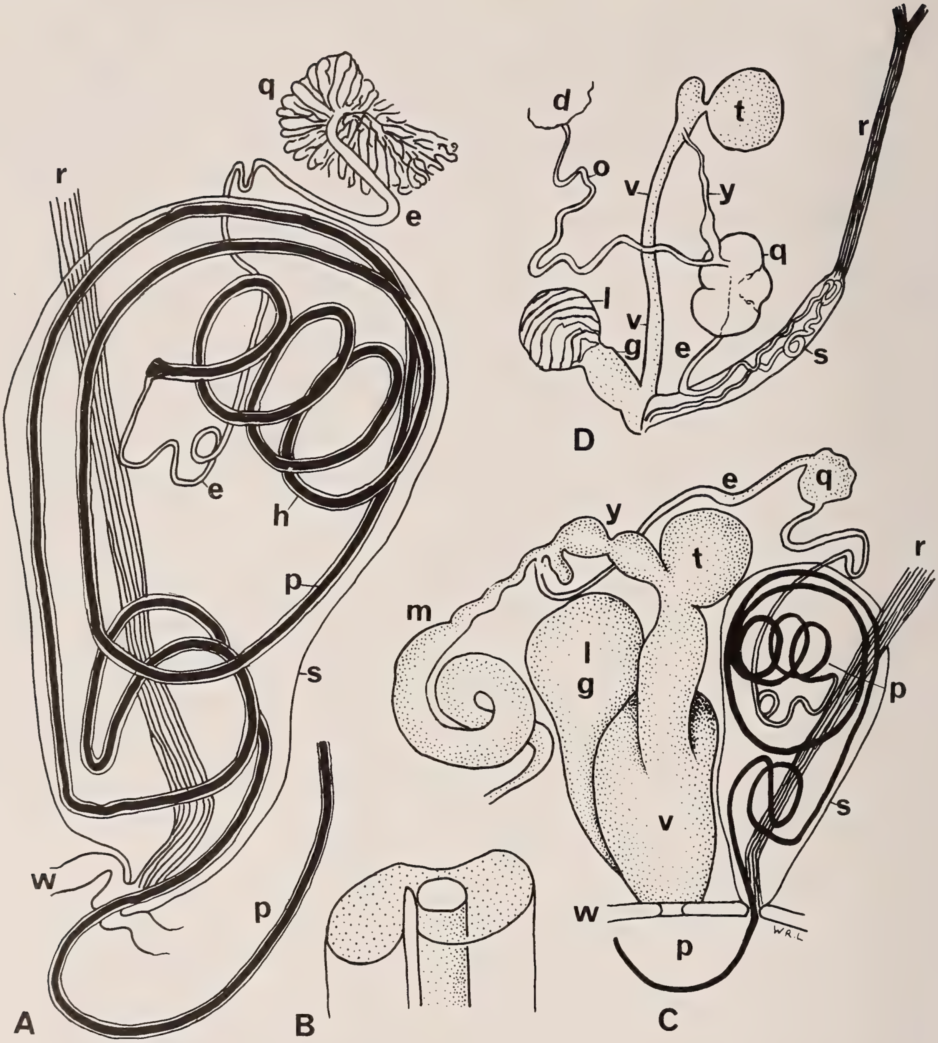

Fig. 2. A–C. *Pleurobranchaea meckelii* Leue, 1813. A. Penial sac. B. Optical section of penial stylet. C. Diagram of reproductive organs. D. *P. maculata* (Quoy & Gaimard, 1832), diagram of reproductive organs (after Vayssière 1901, fig. 247).

Material

Museum National d'Histoire Naturelle, Paris: two specimens, Algiers, Algeria, 1900; five specimens, Mediterranean, Israel to northern Sinai. Zoology Museum, Copenhagen: some dissected incomplete specimens. United States National Museum, Washington, D.C.: P 239, one specimen, Gulf of Guinea (04°56′N 05°00′E).

Distribution

Mediterranean, Atlantic, Azores (Bergh, 1899); Cape Verde Islands (Vayssière, 1902).

Description

Length up to 100 mm. Radular teeth bicuspid, one to five outermost teeth unicuspid. The efferent duct passes transversely through the retractor muscle. In the strongly muscular penial sac it divides into penis proper and penis sheath. The penis is an elastic cuticular stylet, 0,06–0,1 mm diameter, with a high crest (Fig. 1A, H). It forms no more than six to ten loops and is up to 10,5 mm long.

Vayssière's (1901, fig. 223) figure of the structure of the penis, seen by transparence, evidently refers to a young specimen.

Discussion

Bergh's (1897) and Vayssière's (1901) descriptions and figures of *P. meckelii* differ. Vayssière evidently did not have homogeneous material. He indicated a thin, transparent penial sac in *P. meckelii*, but for one of his samples an opaque, nacraeous, muscular one is present. He did not see the elastic cuticular stylet that we found in his Algerian specimen (Fig. 2B) and in the Israeli specimen (Fig. 1A, H). The latter agrees perfectly with Bergh's description and figure (pl. 4, fig. 4) of the penial stylet, while the present specimen from Algiers has a different transverse optical section.

Vayssière (1901: 43) indicated that *P. meckelii* was the only species occurring in the Mediterranean. Therefore, all subsequent findings of Pleurobranchaeidae from the region were identified as *P. meckelii*. However, the present material from Turkey, Israel, and Algeria contains several other species. Even among the three specimens received from the Museum National d'Histoire Naturelle, of Vayssière's material collected in Algiers in 1890, there was one different from *P. meckelii*. It is called here *P. vayssierei* (see p. 38). The specimen from the Gulf of Guinea extends the range of the species. Most of the synonyms assigned to *P. meckelii* are insufficiently described. This is true of Sturany's (1904) description, and the record of specimens from the Red Sea is questionable (Pruvot-Fol 1933: 91). *P. meckelii* var. *occidentalis* Bergh (1897: 28) is actually *P. tarda*.

Pleurobranchaea maculata (Quoy & Gaimard, 1832)

Figs 2D, 25E

Pleurobranchidium maculatum Quoy & Gaimard, 1832: 301–302, pl. 22 (figs 11–14).
Pleurobranchaea maculata (Quoy & Gaimard, 1832) Vayssière, 1901: 49–56, figs 238–247.
Pleurobranchaea novaezealandiae Cheeseman, 1878: 378. Willan, 1983: 254, figs 57–70.

Distribution

Australia, China, Japan, New Zealand, Sri Lanka.

Description

The length is up to about 50 mm.

The radular formula is 40–49 × 80.0.80; ten to fifteen of the outermost teeth lack a secondary denticle.

The reproductive organs described by Vayssière (1901) differ from those of the other now known species by the long vagina ending in a globular caecum to which the spermatheca is connected (Fig. 2D). The efferent duct winding up and down the retractor muscle in the penial sac is similar to that of *P. tarda* (Fig. 5B), but it evidently does not have a stylet.

Discussion

Vayssière (1901: 51) studied specimens of Quoy & Gaimard's (1832) original material and found that Bergh's (1898*b*: 429, pl. 29, figs 2–9) animals from Juan Fernandez were not *P. maculata*. The same must evidently hold for Odhner's (1921: 224) undescribed specimens from Masatierra.

The reproductive organs of a young specimen of *P. tarda* were somewhat similar to those of *P. maculata* in Vayssière's figure, but the spermatocyst and spermatheca are quite different.

The synonymizing of insufficiently described species only because they also come from the Indo-Pacific region (Thompson 1970) cannot be maintained. *P. melanopus* Bergh (1907: 33), *P. japonica* Thiele (1925: 283), and *P. dorsalis* Allan (1933: 445) are possibly synonyms, but *P. tarda* (Fig. 5) is quite distinct from *P. maculata*. *Pleurobranchoides gilchristi* O'Donoghue (1929: 62), a synonym of *Pleurobranchella nicobarica* Thiele (1925: 283), is a species with unicuspid teeth and is also very different from *P. maculata*.

The male organ of Vayssière's (1901: 49–56, figs 238–247) *P. maculata* (Quoy & Gaimard, 1832) from Australia is similar to that of Bergh's (1897, pl. 7, fig. 14) *P. tarda*, but it does not have a stylet.

Pleurobranchaea confusa sp. nov.

Fig. 3

Koonsia obesa Verrill, 1882: 545–546, *partim*. Verrill, 1884: pl. 28 (fig. 7). Verrill, 1885, *partim*.
Pleurobranchaea obesa Bergh, 1897, *non* Verrill: 30–33, pl. 7 (figs 19–21). Vayssière, 1901, *non* Verrill.

Type material

Holotype: United States National Museum 784657, off Delaware Bay (38°35′N 73°13′W), 400 m, 10 October 1881. This specimen was previously a paratype of *Koonsia obesa*.

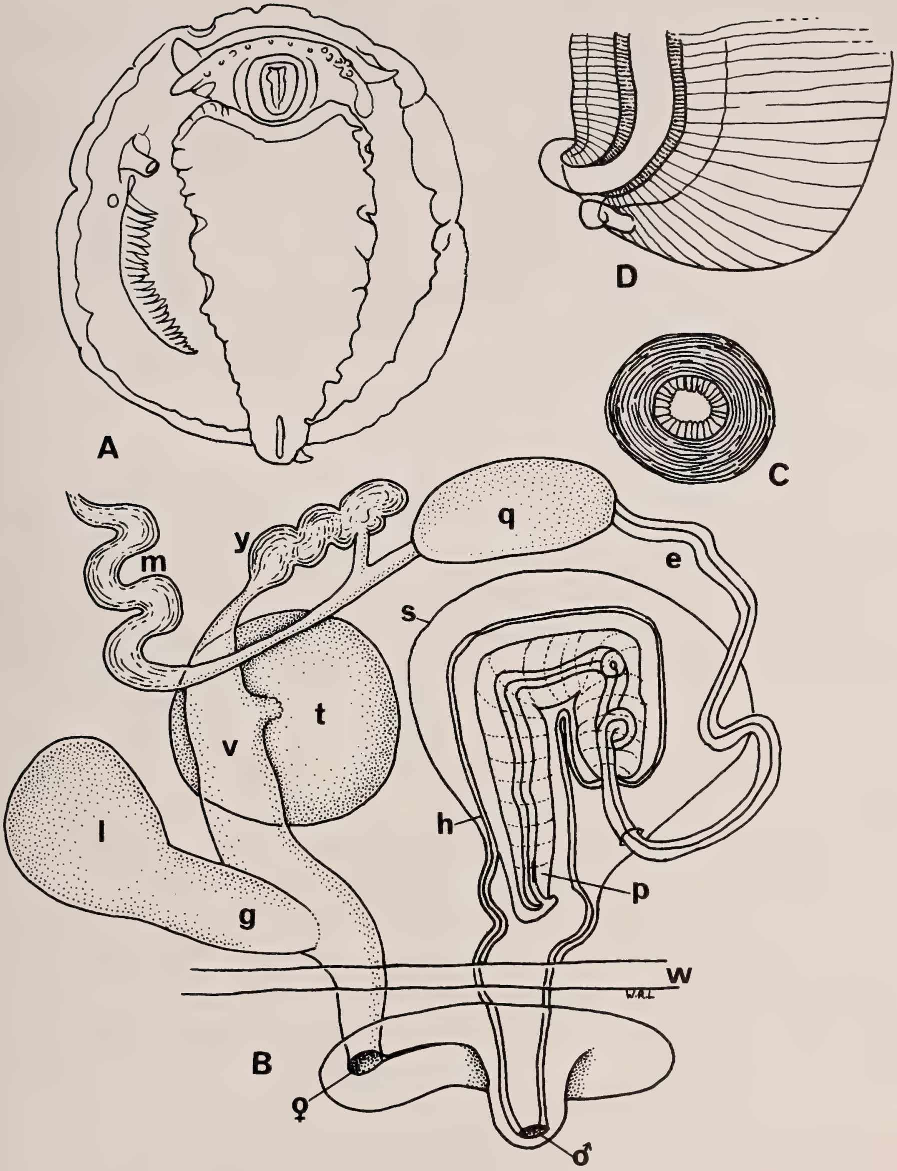

Fig. 3. *Pleurobranchaea confusa* sp. nov. A. Ventral view of preserved specimen (paratype of *Koonsia obesa*). B. Diagram of reproductive organs. C. Optical section of efferent duct in penis. D. Tip of penis.

Further distribution

? Off Martha's Vineyard, Massachusetts.

Etymology

The epithet *confusa* (from Latin: *confusio*) refers to the combination of two distinct species in the original description of *Koonsia obesa*.

Description

The present contracted animal is 4,5 by 4,0 cm and has a smooth, swollen notum extending far out over the foot (Fig. 3A). The oral veil has a single row of papillae. The tentacles and rhinophores are smooth. The triangular foot is narrower and shorter than the notum. It has a broad anterior border, a dorsal spur, and a ventral foot gland (Fig. 3A). The gill has about twenty-six pinnae and a smooth rachis.

The denticles on the jaw platelets are irregular in presence and in size; there are two to twelve denticles per platelet. The radular formula is 34 × 90.0.90. Approximately fifteen of the outermost teeth of each row are unicuspid. There is no rachidian tooth.

The male duct enters the prostate and, after leaving it, winds to enter the wide penial sac. Inside the sac it forms a wide sheath and a strongly muscular penis with two tiny cuticular bulbs at its tip (Fig. 3D). The oviduct has some epithelial pouches, the spermatocyst. The oviduct widens and receives the large spermatheca. The wide vagina continues, joining with the female gland mass, and opens through the female aperture (Fig. 3B).

Discussion

This description is based on a paratype of *Koonsia obesa* from Verrill's collection and corresponds to the paratype studied by Bergh (1897: 30–33, pl. 7 (figs 19–21)). It differs from Verrill's (1884, 1885) figures by the swollen and overhanging mantle, elongate tail and the absence of 'small hooks on the verge'. Bergh was quite right to transfer this material to *Pleurobranchaea*. However, specimens of the type species of *Koonsia*, *K. obesa* Verrill, 1882, may be found again. The name *Pleurobranchaea confusa* sp. nov. is proposed for the paratype of *Koonsia obesa*.

Pleurobranchaea tarda Verrill, 1880

Figs 4–5

Pleurobranchaea tarda Verrill, 1880: 398; 1882: 546, pl. 58, (fig. 26). Bergh, 1897: 33, pl. 6 (figs 28–31), pl. 7 (figs 1–15). Vayssière, 1901: 57, figs 248–251.
Pleurobranchaea tarda var. Bergh, 1897: 39, pl. 7 (figs 21–27).
Pleurobranchaea meckelii var. *occidentalis* Bergh, 1897: 28. Vayssière, 1901: 46.
Pleurobranchaea occidentalis Bergh, 1897. Marcus & Marcus 1967*a*: 45.
Pleurobranchaea capensis Vayssière, 1900. Vayssière, 1901: 46, pl. 4 (figs 232–237). O'Donoghue, 1929: 48, figs 52–57. White, 1955: 173, fig. 6.
Pleurobranchaea maculata Thompson, 1970: 192, *partim.*, *non* Quoy & Gaimard.

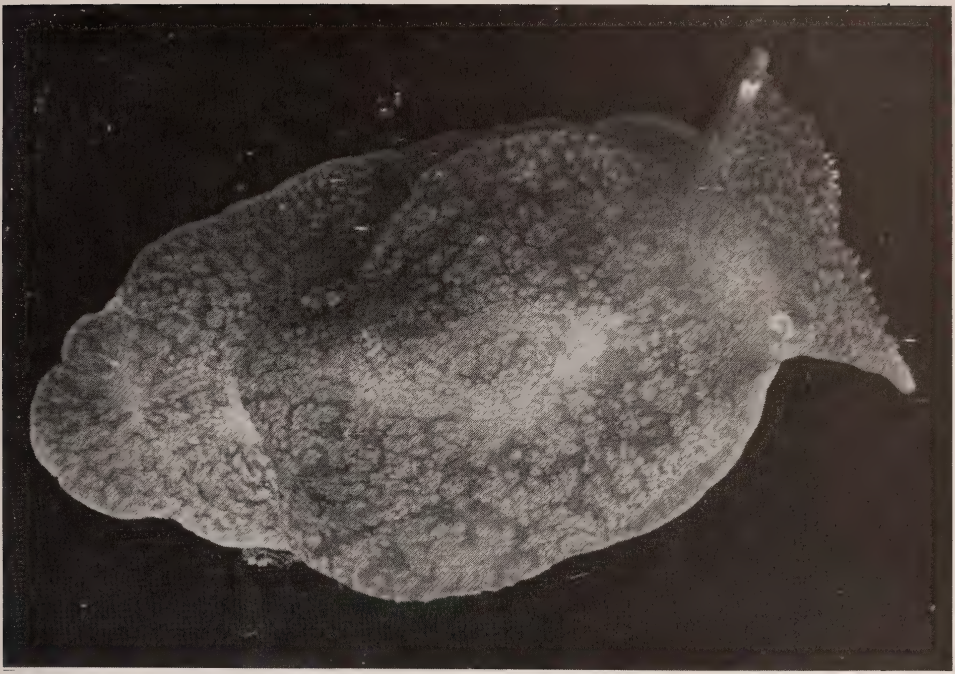

Fig. 4. *Pleurobranchaea tarda* Verrill, 1882, living animal.

Material

About 120 specimens in the U.S. National Museum and South African Museum; western Atlantic, from 31° to 5°N; eastern Atlantic from Ghana and the Cape of Good Hope and False Bay; intertidal to 1 450 m.

Further distribution

From Martha's Vineyard to south of Cuba; Angola and Kabinda; Agulhas Bank (35°10′S 23′E), 500 m.

Description

The present animals preserved, are from 7,5 to 52 mm long. The mantle is generally smooth and about the same size as the foot. On its right side the border often forms an exhalant siphon over the anal opening and the tip of the gill. The tip of the foot often extends posteriorly (Fig. 5C). In some specimens it bears a short spur. The metapodial gland on the end of the sole is rarely developed. The veil, tentacles and rhinophores are typical for the genus. The tubercles of the veil are sometimes preserved. The proboscis is often protracted, and the anterior border of the jaw plates are as variable as in *P. gela* (Marcus, Ev. & Marcus 1966, fig. 35).

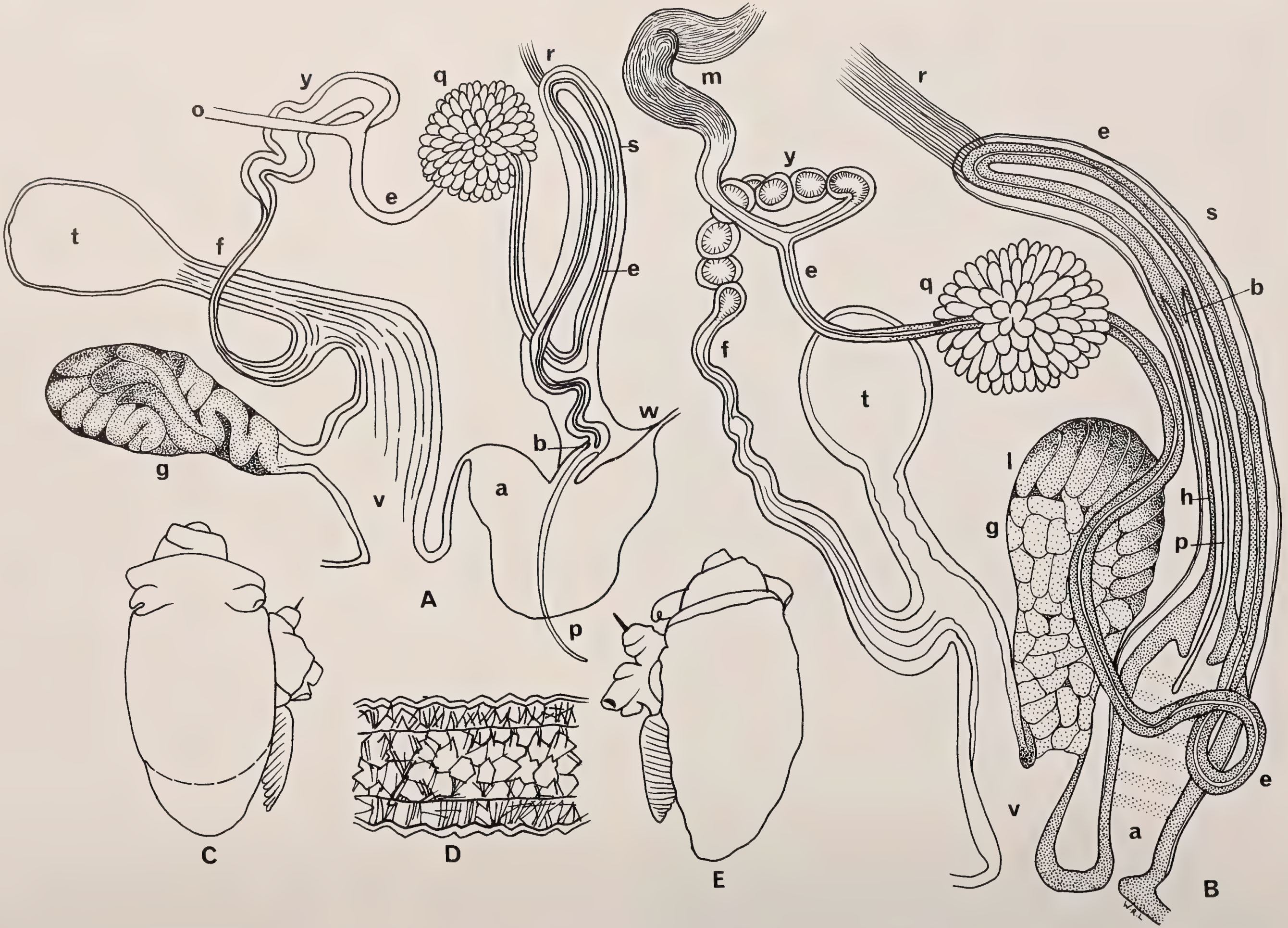

Fig. 5. *Pleurobranchaea tarda* Verrill, 1882. A. Reproductive organs of Nigerian specimen. B. Reproductive organs of western Atlantic specimen. C. Dorsal aspect. D. Part of stylet. E. Ventral aspect.

The gill is adnate for about two-thirds of its length. The anus lies dorsally, just in front of the gill membrane. The number of pinnules of the gill varies from twelve to thirty pairs. They alternate and often begin with a tubercle, so that the rachis appears tuberculate. In some animals the gill is regenerating. The genital apertures lie in the middle of the body or slightly anteriorly. According to their state of contraction or eversion they are flat, small and round, with or without a flap. The male atrium is partly everted and the tip of the cuticular penis is projected in about twenty of the present specimens (Figs 5C, E). In an animal of 10 mm the tip of the cuticular penis was well developed and stuck out of the male aperture.

The radular teeth are bicuspid except for about six of the outermost ones.

From the ampulla (Fig. 5A–B) the thin common genital duct (o), divides into male (e) and female (f) ducts. The latter recurves backward along the common duct. It is much wider initially, forming a ciliated serial spermatocyst. Vayssière (1901: 49) thought this was a caecum of the common duct, from which the efferent duct went out. Farther outward the female duct, which functions as both oviduct and insemination duct, is rather wide and has a high ciliated epithelium. The narrow efferent duct is surrounded by a ball of fine branching prostatic gland tubules (q). As it leaves these tubules, it widens and loops around the male atrium, entering the narrow penial sac (s) and traversing the retractor muscle (r) for up to 7 mm. It then turns outward and reaches the fundus of the atrium (a). The length of the efferent duct varies considerably along the retractor muscle and within the atrium. If the penial sac remains intact during preparation, the aspect of the duct is as in Bergh's (1897: pl. 7 fig. 14) figure. When it is torn, it appears like Vayssière's (1901, fig. 249) figure. In its descending course the efferent duct is separated into a sheath (h) and the cuticular penis proper (p). This is a stylet of 0,12 mm diameter at its base, narrowing to 0,08 mm in diameter. Its length varies from 1,9 to 6 mm. The chitinous penis enters the atrium through a small papilla. The penial cuticle is rough on the outer side (Fig. 5D). Vayssière's (1901, fig. 25D) figure of the tip of the penis corresponds to our observations, but we cannot confirm his interpretation of its muscular nature.

The oviduct begins with a winding spermatocyst and continues to widen slowly to the stalk of the spermatheca (t). The vagina (v) is short and wide and receives the outlets of the albumen and mucous glands. The atrium is generally long and narrow when inverted, or short and wide when partially everted. Its epithelium contains transverse bands of glandular cells.

Discussion

Both Bergh and Vayssière studied specimens from Verrill's original material, but neither of them observed the cuticular stylet. They figured only the tip of the penis (Bergh 1897, pl. 7 (fig. 27); Vayssière 1901, fig. 250). Vayssière considered the penis of his specimens (30–40 mm alive, 14–16 mm preserved) incompletely developed. In the present material a preserved animal 7,5 mm in length had a well-developed cuticular penial stylet. The inward loop of the efferent duct in Bergh's (1897, pl. 7 (fig. 14)) figure is held together by the penial sac, while in Vayssière's figure it is loose.

Bergh (1897: 28–30, figs 16–18) described *Pleurobranchaea meckelii* var. *occidentalis* from Martinique. Marcus, Ev. & Marcus (1967*a*: 45–48, fig. 55A–C) identified specimens from Florida with Bergh's form and raised this to species level due to the different penial sac. Marcus & Marcus figured the penis in its sheath (their fig. 55C). Comparing this and the present animals with *P. tarda* in Vayssière's figure 249, the authors did not find any difference and consider *P. occidentalis* as a synonym of *P. tarda*.

Pleurobranchaea capensis was described from two specimens from the Cape of Good Hope collected in 1829. Vayssière (1901: 46–49, figs 232–237) described the inward loop of the efferent duct as being similar to that of *P. tarda*. However, it did not have a loop around the atrium (Fig. 5A).

Bergh (1907: 30) identified twenty-seven of his South African specimens as *P. capensis* Vayssière, with the 'vas deferens much shorter than in *P. meckelii*'. One specimen Bergh (1907: 32, pl. 11 (figs 1–8)) called *P. capensis* var., because it had a 'much longer vas deferens than represented by Vayssière (fig. 232)'. The present ample material showed a high variability of the length of the male duct. The extremes corresponded to those described for *P. tarda* and *P. capensis*. Hence *P. capensis* Vayssière must be considered as a junior synonym of *P. tarda* Verrill.

Pleurobranchaea brockii Bergh, 1897

Figs 6–8

Pleurobranchillus brockii Bergh, 1892: 28, *nom. nud.*
Pleurobranchaea brockii Bergh, 1897: 41–46, pl. 4 (figs 8–17). Vayssière 1901: 62–69, figs 255–260. ? Farran, 1905: 355, pl. 5 (figs 24–28). White, 1948: 20. Macnae, 1962: 178. Lin Guangyu & Tchang Si, 1965: 275, pl. 1 (fig. 3).
Pleurobranchaea brockii var. Bergh, 1897: 46–47, pl. 7 (figs 33–38), pl. 8 (fig. 1).
Pleurobranchaea gemini Macnae, 1962: 178, fig. 7a–c.

Material

South African Museum: SAM–A29866, two specimens, no locality; SAM–A30078, one specimen, no locality; holotype *P. gemini*, SAM–A35234, Inhaca Island, collected by W. Macnae, 18 July 1958; paratype *P. gemini*, SAM–A35236, Inhaca, collected by W. Macnae, 19 July 1958; SAM–A35237, two specimens and egg mass, Inhaca Island, collected by W. Macnae, December 1967.

Distribution

Japan to South Africa.

Description

The preserved specimens are 38–110 mm long. The notum is smooth or mamillate. The colour, when preserved, is a net of black pigment around more or

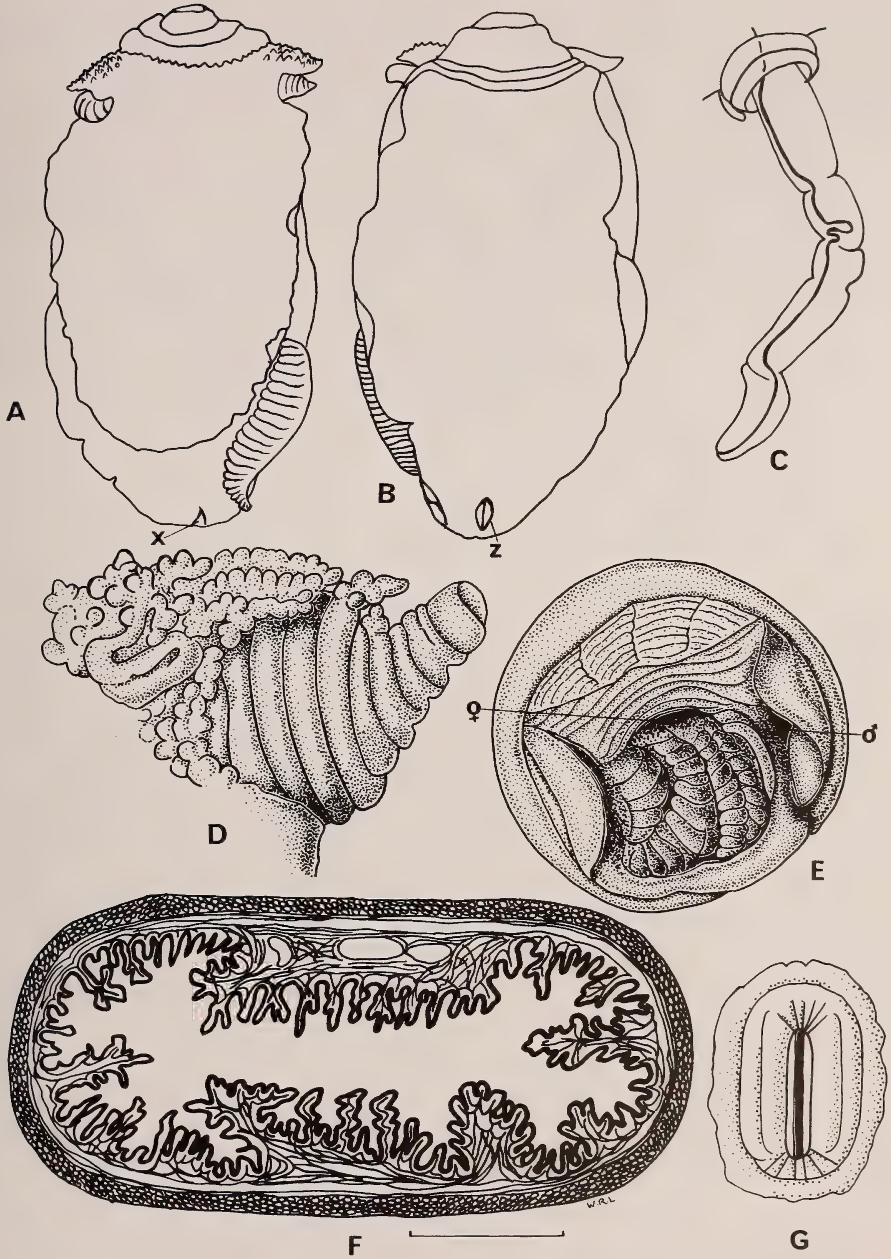

Fig. 6. *Pleurobranchaea brockii* Bergh, 1897. A. Dorsal view of preserved specimen. B. Ventral view. C. Extruded penis. D. Tentacle and rhinophore. E. Gonopore. F. Transverse section of vagina, scale 0,5 mm. G. Anterior of pharynx with borders of jaws.

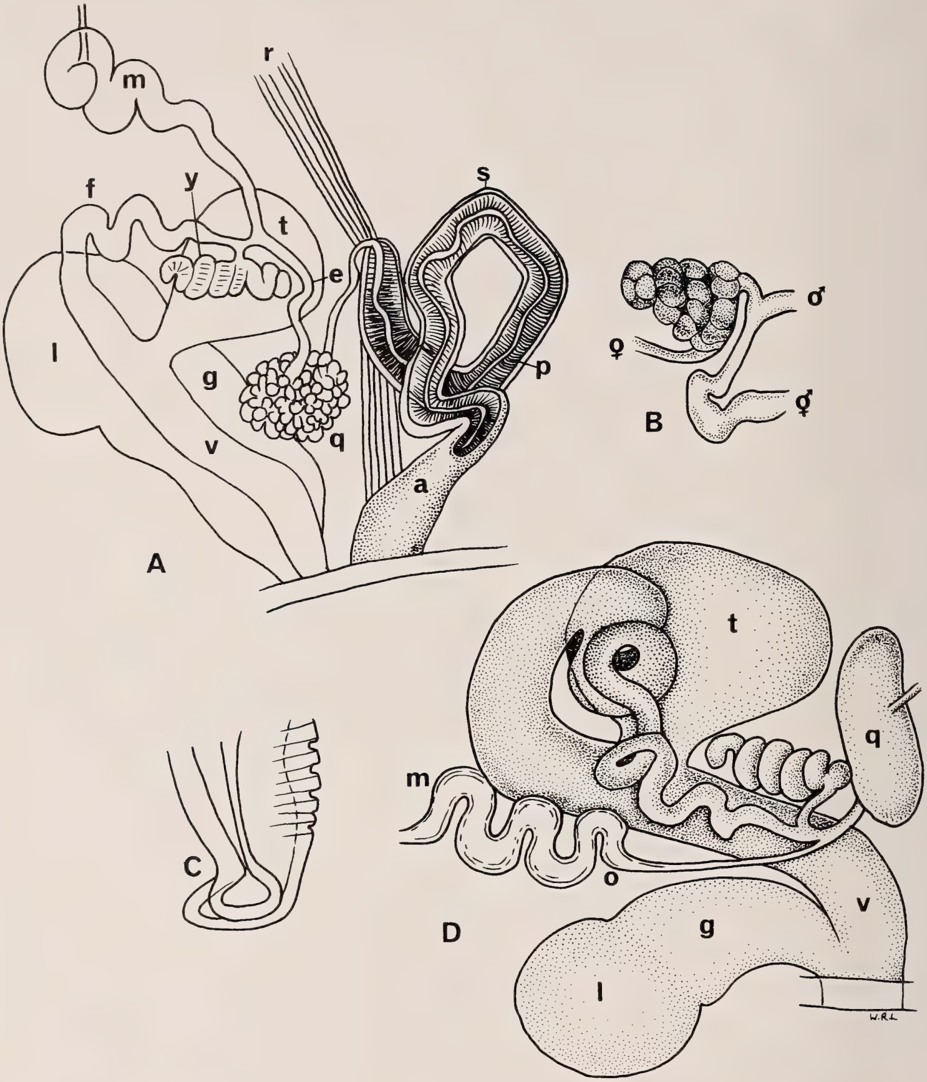

Fig. 7. *Pleurobranchaea brockii* Bergh, 1897. A. Diagram of reproductive organs of specimen SAM–A30078. B. Spermatocyst. C. Tip of contracted penis. D. Female organs.

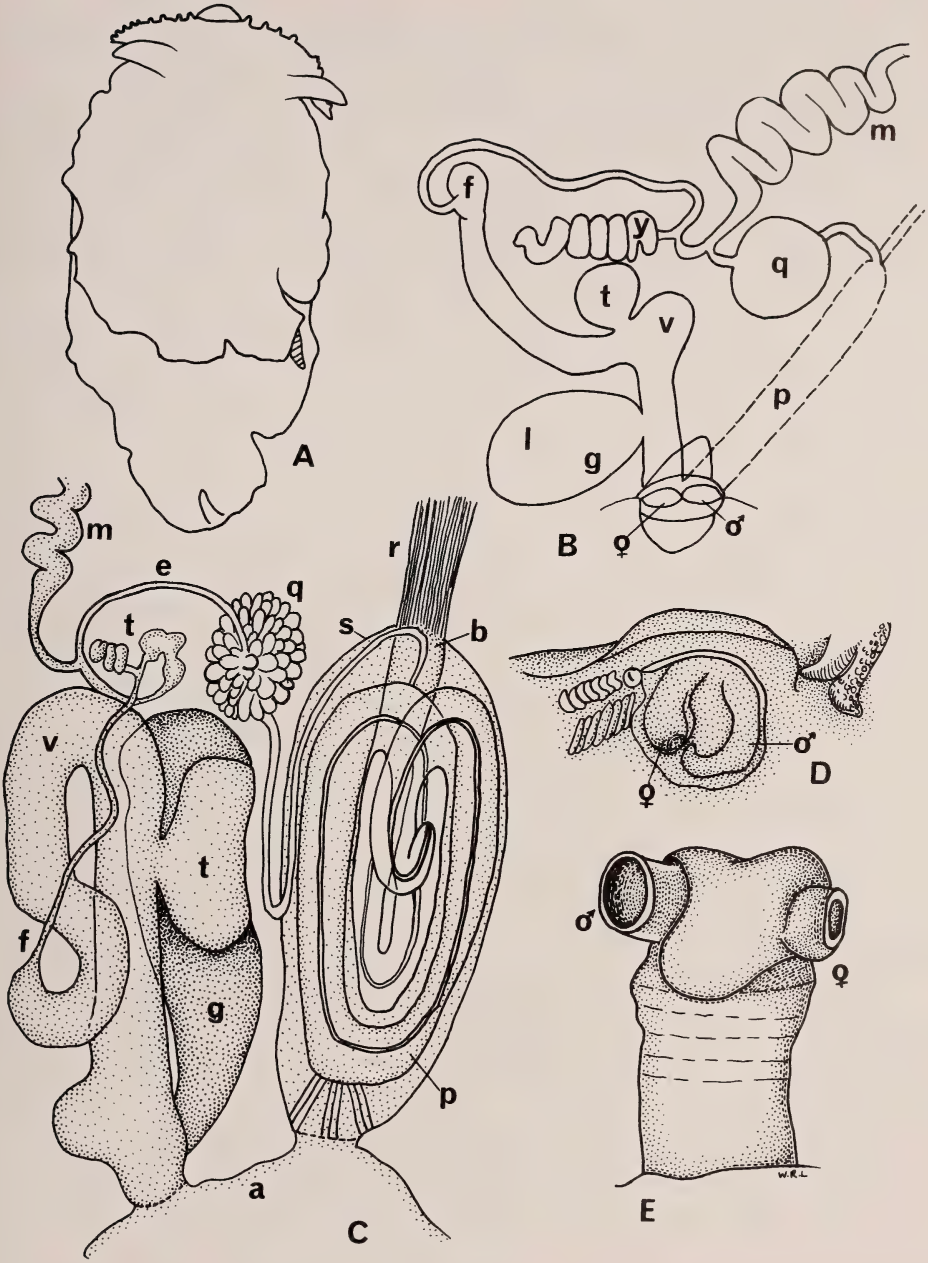

Fig. 8. *Pleurobranchaea brockii* Bergh, 1897, paratype of *P. gemini*. A. Dorsal view of preserved specimen. B–C. Reproductive organs. D. Gonopore with a partially everted atrium. E. Everted male and female pores.

less regular light circles or big blotches, which contain mamillae. Pigment is also present on the upper side of the foot. The notal border is free around its entire surface. There are sixteen papillae on the border of the oral veil arranged in two rows. The anterior side of the tentacles is thickly papillate in the South African Museum specimens (Fig. 6A, D). In those from Inhaca there are fewer tubercles (Fig. 8A). The rhinophores are set in deep sinuses between the tentacles and notum. The foot projects further posteriorly in the specimens from Inhaca (Fig. 8A), but this may be an artifact of preservation. A spur and a foot gland are present or absent. The gill rachis is narrow; the base of the 30–40 pairs of pinnae may bear a knob.

The jaw plates have a straight anterior border (Fig. 6G). Their denticles are present or absent and are irregular in number and size. The radular formula is 40–48 × 65–90.0.65–90. The teeth are bicuspid but the outermost laterals are sometimes unicuspid. Vayssière (1901, fig. 260) mentioned and figured a rachidian tooth, but said it was atrophied and often lost or absent. It seems to be the fused first laterals. The radula of the holotype specimen of *P. gemini* is missing. Those of the paratypes are, like that of *P. brockii*, without a rachidian tooth.

The male duct passes through the prostate (Fig. 7A) and enters the narrow penial sac (s). There it forms a strong muscular, non-cuticularized penis (p). The retractor muscle inserts on the middle of the dorsum and traverses the sac to the atrium. In a contracted state the penis is curled (Fig. 8C). When extruded it is up to 4 cm long (Fig. 6C). The shape of the atrium could not be determined. When everted it is a wide and very thin sac (Fig. 8D), and when completely extruded the male and female pores open on its innermost stronger part (Fig. 8E). The gonopore is surrounded by a circular fold with some flaps.

The oviduct, after separating from the common duct, has a swollen part (Bergh 1897, pl. 4 (fig. 8)), that sometimes forms a small caecum lying at the beginning of the spermatocyst (Fig. 7A). In most specimens the latter forms a longer caecum with three to five spirals, but rarely it is only a widening with epithelial pouches in the duct. The duct narrows into several whorls and then widens suddenly as the vagina. The vagina is long (Bergh 1897: 46) and its epithelium is divided into many folds (Fig. 6F). Farther outwards the spermathecal pouch opens into the vagina. The vagina joins the albumen and mucous glands. It often has an ectal widening on one side.

The holotype of *P. gemini* had previously been opened only for the radula. The female organs were intact (Macnae 1962, fig. 7c). The male organ was examined for comparison. It corresponds to Bergh's (1897) figure. The spawn is a tall convoluted ribbon 13 mm wide, like that of *P. californica*.

Discussion

The descriptions of *P. brockii* and *P. gemini* are similar, and Macnae's distinctive characters are not convincing: *P. brockii* 'is characterized by a mamelonated mantle' while the 'smooth, not mamillated surface' of *P. gemini* is not mentioned in the description, only in the comparison. In some of Macnae's paratypes which we observed the mantle was smooth, in others mamillate.

In all available specimens the sixteen velar papillae are set in two rows. In the South African Museum specimens SAM–A29866 and SAM–A30078, the tentacles are thickly covered with papillae (Fig. 6D), while in Macnae's animals there are only a few. This merely represents intraspecific variation. Bergh found no trace of rachidian teeth in the radula of *P. brockii*. In Macnae's (1962: 178) specimen of *P. brockii* they were 'very deciduous and all had fallen off . . . and were found in the debris at the bottom of the watch glass'. In *P. gemini* they were not mentioned. Macnae's figure shows very long primary cusps and the secondary cusp inserting near the base, but he (1962: 180) noted that they were 'without the basal prominence on the inner edge'. The teeth of the paratypes of *P. gemini* that were examined are like those of *P. brockii*. The radulae of ten specimens were studied and a basal prominence was found in all specimens. It is sometimes not visible when the teeth are tilted and this fact may explain why Macnae did not notice the prominence in the holotype.

The 'long and worm-like penis' of *P. gemini* described by Macnae (1962: 180) was not figured. Bergh (1897, pl. 4 (fig. 8)) and Vayssière (1901, fig. 256) illustrated the large, soft, non-cuticular penis of *P. brockii*. A second caecum on the outer oviduct of *P. gemini*, to which the spermatheca is attached (Fig. 8B), is not recognizable in Bergh's figure of *P. brockii* nor in the dissected specimens from Inhaca. Based on the variability observed in Macnae's type material and the similarity of it to *P. brockii*, the two species are thought to be synonymous.

Pleurobranchaea agassizii Bergh, 1897

Fig. 9

Pleurobranchaea agassizii Bergh, 1897: 48, pl. 7 (figs 28–32). Marcus & Marcus, 1967*a*: 49, 51, fig. 56A–D.

Distribution

Straits of Florida; Great Bahama Bank, 262–620 m.

Description

Length up to 10 cm; radular formula 32 × 98.0.98. About seventeen of the outermost teeth lack the secondary denticle. The efferent duct (Fig. 9E) does not enter the penial sac but, where the retractor muscle is attached to it, it divides into a sheath and a muscular penis without cuticle. (After Marcus, Ev. & Marcus, 1967*a*).

Discussion

In Marcus & Marcus's (1967*a*: 49–51) description there were two errors. P. 51: the allosperm duct does not rise through the efferent duct but through the vagina and insemination duct, which is the outer oviduct. In figure 56D the ovi-

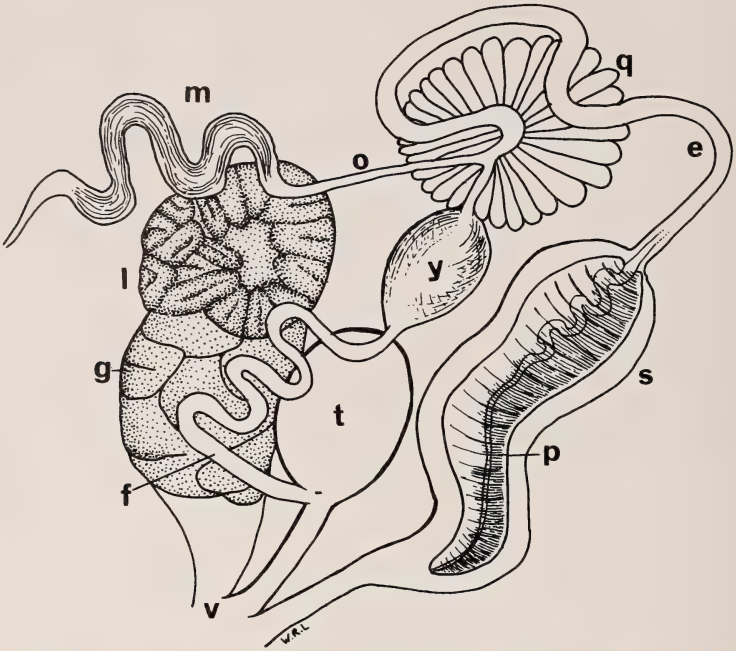

Fig. 9. *Pleurobranchaea agassizii* Bergh, 1897, Reproductive organs.

duct is shown entering the albumen gland; actually, it only passes near the female gland mass and continues to the vagina, where it receives the secretions of the albumen and mucous glands.

Pleurobranchaea inconspicua Bergh, 1897

Figs 1B, 10–11

Pleurobranchaea inconspicua Bergh, 1897: 49, pl. 8 (figs 2–10).
Pleurobranchaea hedgpethi Abbott, 1952: 1, pl. 1 (figs 1–8). Marcus & Marcus, 1959: 253, fig. 6. Marcus, Er., 1961: 141. Marcus & Marcus, 1967*b*: 200. Marcus & Marcus, 1969: 18. Nijssen-Meyer, 1965: 143, figs 1–3.
Pleurobranchaea gela Marcus & Marcus, 1966: 174, figs 35–37. Marcus & Marcus, 1968: 1336.

Material

About twenty-five specimens from 37°N to 5°N, 54°W to 86°W, 27–310 m; one specimen from Atlit, Israel.

Further distribution

From Cape Hatteras to Argentina; Texas; Ivory Coast to Nigeria.

Description

The preserved animals range from 11 to 55 mm in length and are in various states of contraction. Often the buccal mass is everted around the large

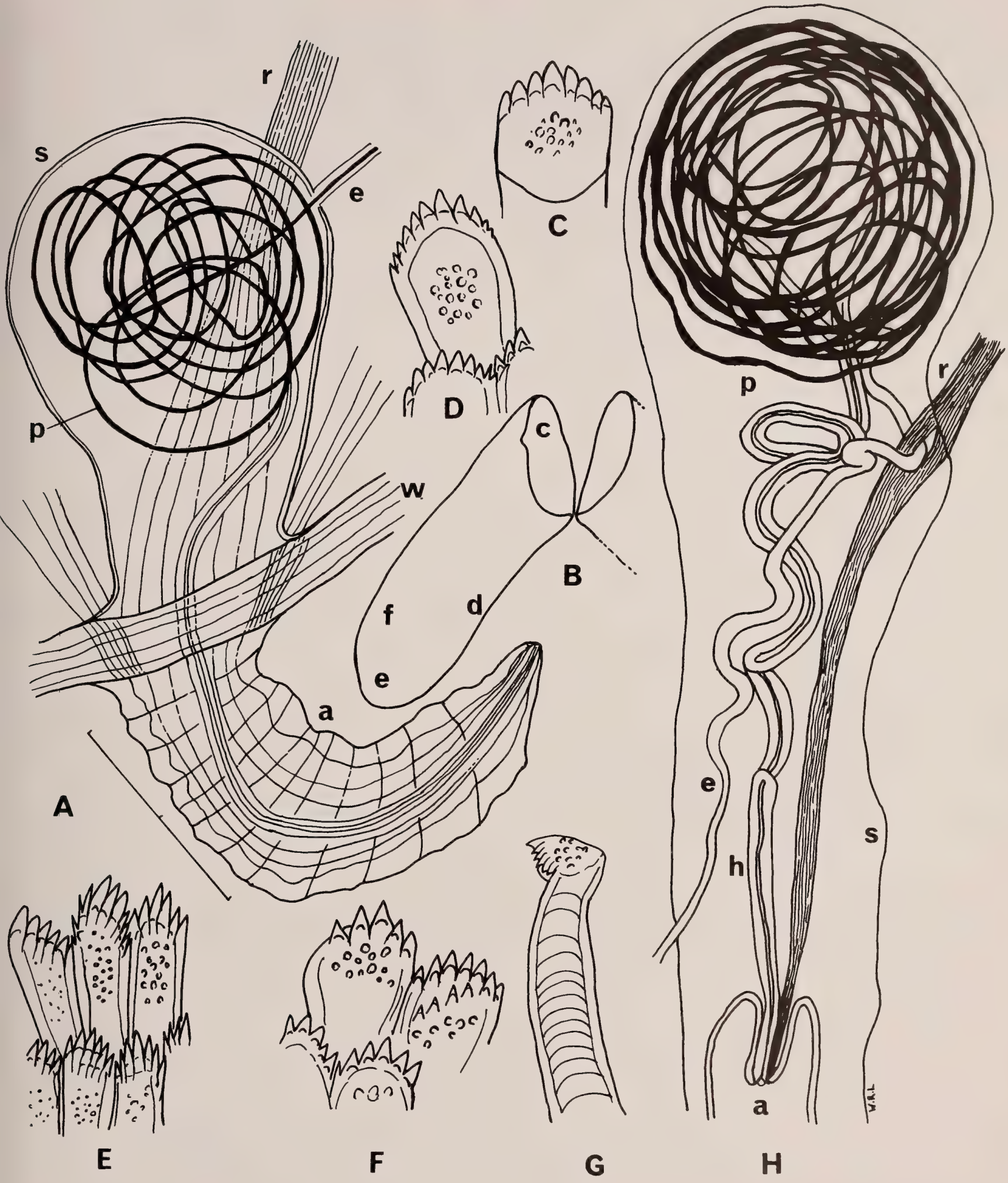

Fig. 10. *Pleurobranchaea inconspicua* Bergh, 1897. A. Everted penis, scale 2,0 mm. B. Jaws showing location of platelets in C–F. C–F. Platelets from various locations. G. Lateral view of platelet. H. Penis of specimen from Israel.

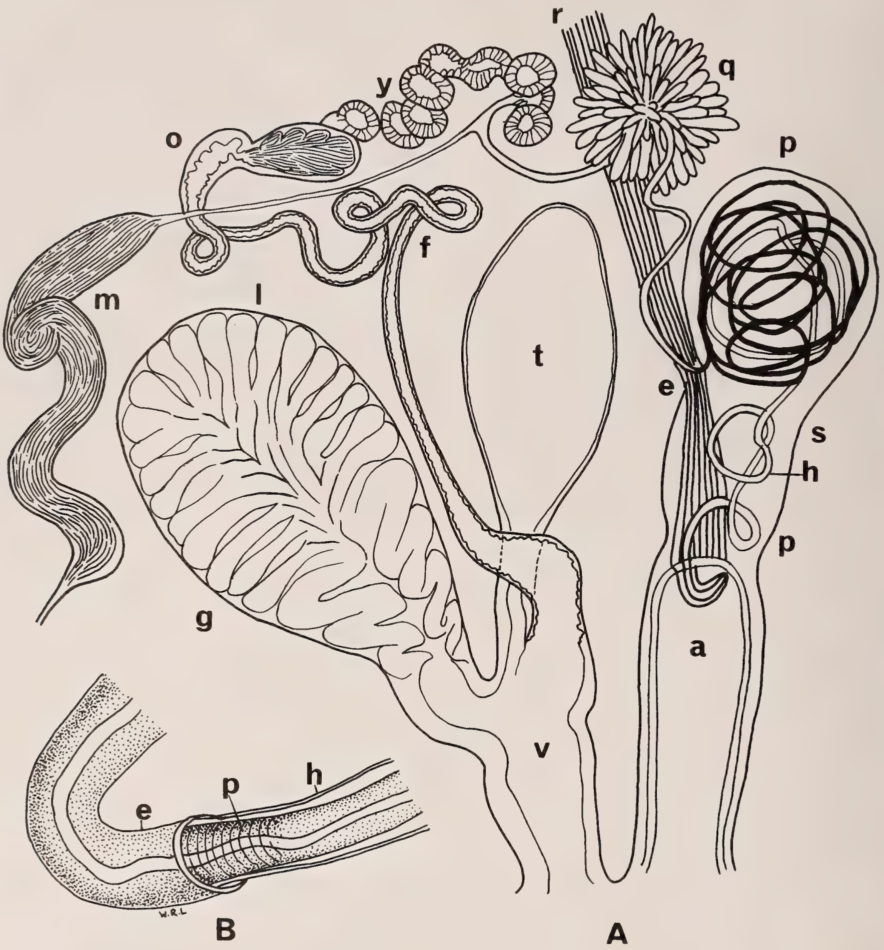

Fig. 11. *Pleurobranchaea inconspicua* Bergh, 1897. A. Diagram of reproductive organs. B. Root of penis and penis sheath.

projected pharynx. The anterior borders of the jaw plates are then visible, and sometimes even the radula. Also the male atrium can be everted (Fig. 10A), and the cuticular penial stylet may be observed. The notum is smooth or has some bosses separated by pigment, which is sometimes retained in these furrows.

The jaw plates of a 15 mm long animal were 4,6 × 2 mm. In a 26 mm specimen they were 5 × 1,6 mm. They are colourless in small specimens and light brown in the largest ones. The platelets are composed of columnar rodlets whose surface is often hexagonal. Their length varies according to their position in the jaw and with the size of the animal. The anterior border has a row of five to fifteen denticles and often some knobs on the surface. These both can be lost in the anterior, oldest part of the jaw plate.

The radular formula is 32–40 × 55–68.0.55–68. The lateral teeth are bicuspid as in other species of *Pleurobranchaea*, largest in the middle of the half-row and smaller towards the outer border. Up to twenty outer teeth lack a secondary denticle.

The ovotestis and hermaphroditic duct are typical of the genus, as are the male duct and prostate (Fig. 11A). The male duct is 0,13 mm in diameter. Beyond where the male duct enters the penial sac, it is surrounded by a sheath (Fig. 11B). Its lumen is cuticularized and stiffens the duct so that it forms up to twenty roundish loops (Fig. 10H). This is the eversible penis proper, which may reach 14 mm in length when extended. It is ovoid in transverse view, and flattened on one side. Its lumen is circular or higher than broad (Fig. 1B). Ectally it gradually tapers to its tip. It is difficult to find the point where the penial sheath is separated from the penis proper, owing to the many loops of the efferent duct. Therefore it was not distinguished in the figures of the penial sac. The sheath is about 0,34–0,40 mm in diameter at its outer part. It ends forming a small papilla in the fundus of the male atrium. The papilla is up to 7 mm long and 2 mm wide. The entire male organ reaches 20 mm in length. The atrium can be everted for copulation (Fig. 10A) and the cuticular stylet projected. The smallest animal with a cuticular penis was 11 mm long. In material from 40°S, up to 20 mm long, specimens still did not have genital apertures (Marcus, Ev. & Marcus 1969: 20).

Discussion

Pleurobranchaea inconspicua, of which Bergh had a single specimen from Brazil (Sergipe), is identical in all its described characters with *P. hedgpethi* Abbott, 1952. Hence it is considered as a senior synonym of *P. hedgpethi*. The insemination ducts of *P. hedgpethi* (Marcus, Ev. & Marcus 1959, fig. 6) and *P. gela* (Marcus, Ev. & Marcus 1966, fig. 37) were figured differently. These differences appear to be a result of their state of contraction. Marcus, Ev. & Marcus (1967*a*: fig. 56) illustrated the insemination duct of *P. hedgpethi*. It has two vesicles as described for *P. gela*. In the present collection both forms occur. It is believed that *P. gela* is also a junior synonym of *P. inconspicua*.

Pleurobranchaea augusta sp. nov.

Figs 1C, 12

Type material

Holotype: United States National Museum 809995, West Africa (17°02′S 11°40′E), 54 m.

Etymology

From the Latin *augustus*, meaning venerable.

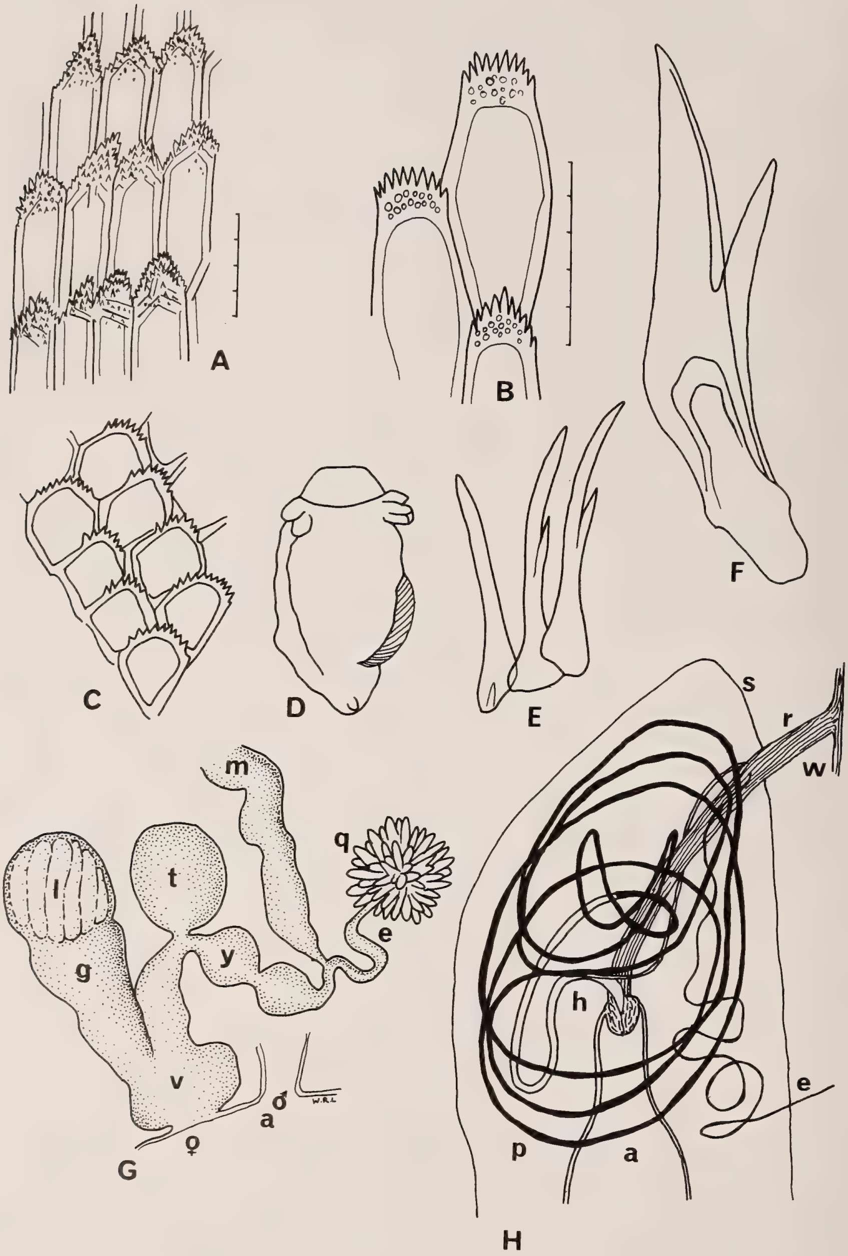

Fig. 12. *Pleurobranchaea augusta* sp. nov. A. Jaw platelets from middle of jaw, scale 40 μm. B. The same, from front of jaw, scale 50 μm. C. The same, from near border of jaw. D. Preserved animal. E. Outermost teeth. F. Radular tooth from middle of half-row. G. Female organs. H. Penial sac.

Description

The animal is 32 mm long, 20 mm broad, and 15 mm high, in the preserved state (Fig. 12D). It is colourless. The smooth notum forms an exhalant siphon over the tip of the gill. It is smaller than the foot. The foot has a tiny spur and a weak metapodial gland. The oral veil, tentacles and rhinophores are contracted. The gill has a smooth rachis with about twenty pinnae on either side. On the base of each of the pinnae there is a knob. Four-fifths of the length of the gill are adnate. The labial cuticle bears conical papillae. The platelets of the jaws vary in shape according to their position on the jaw. The central ones (Fig. 12B) have a long narrow surface with about ten denticles and some small tubercles behind them. The marginal platelets appear roundish with less numerous and shorter denticles (Fig. 12C). The radular formula is 40 × 70.0.70. The teeth are bicuspid (Fig. 12F) except for one or two of the outermost ones (Fig. 12E).

Ectally from the ampulla the hermaphroditic duct divides into the male efferent duct, and the oviduct (Fig. 12G). The former passes through the prostate and enters the thin, roundish penial sac in its middle. The efferent duct winds upward to the entrance of the retractor muscle which it penetrates (Fig. 12H). Later it divides, widening slightly, into the penial sheath and cuticular, stiff penis proper. Together the penis and its sheath form about six loops. In the present specimen the penis ends before the sheath opens into the atrium with a small papilla.

The penial cuticle is cylindrical with equally thick walls. It forms a sharp crest (Fig. 1C), which is visible in optical transverse section. This crest serves as the distinctive character separating *P. augusta* from *P. meckelii*, whose cuticle is more irregular. The globular spermatheca connects directly to the oviduct. The oviduct widens to form a short vagina into which the accessory female glands open. The female aperture is slightly posterior to the male aperture.

Discussion

The single specimen is similar to *P. meckelii*, but the shape of the penial stylet differs (Fig. 1C, 2B), and the vagina is longer in *P. meckelii* (Fig. 2C).

Pleurobranchaea bonnieae sp. nov.

Figs 1D, 13–14

Type material

Holotype: United States National Museum 809999, R. V. *Gerda*, Station G 1001, Florida (27°N, 80°W), 61 m, 21 May 1968, one dissected specimen and slides of the jaws, radula and genital organs.

Etymology

This species is named for Bonnie J. Gosliner.

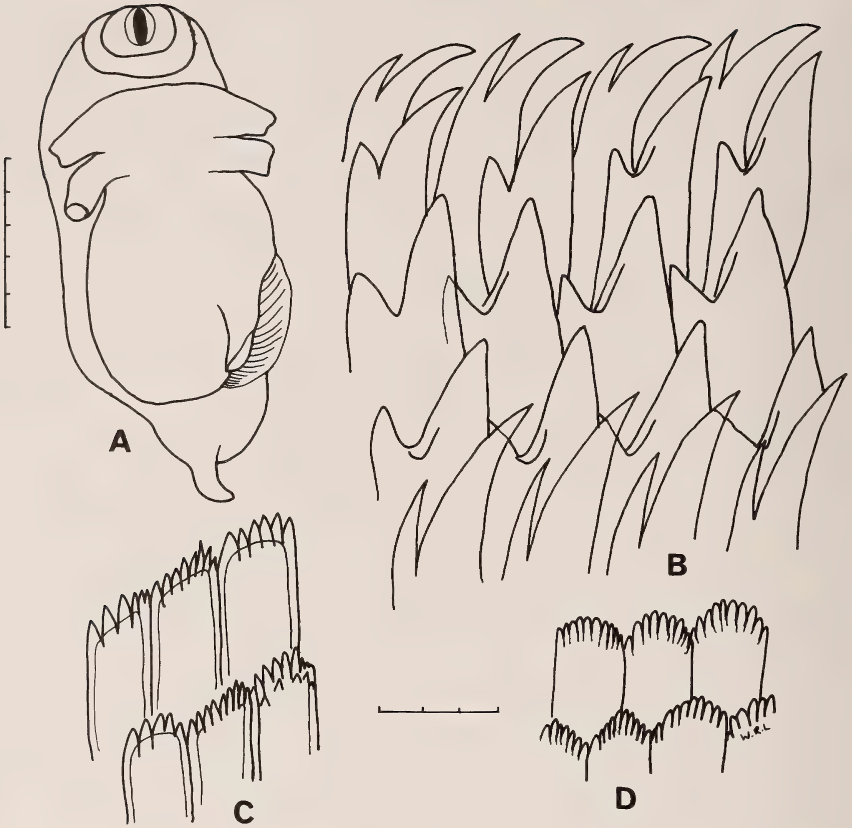

Fig. 13. *Pleurobranchaea bonnieae* sp. nov. A. Dorsal view of preserved animal, scale 5 mm. B. Abnormal rows of radula. C–D. Jaw platelets, scale 0,03 mm.

Description

The preserved animal is 15,5 mm long and 7 mm wide. Its mantle is slightly tuberculate, white, with bits of pigment retained on the rhinophores and the mantle. The foot is shorter than the notum anteriorly and longer posteriorly (Fig. 13A). The contracted oral veil is short and smooth. On the hind end of the foot is a prominent spur. A pedal gland was not observed. The gill rachis is smooth with about twenty pinnules on either side. The prebranchial gland opens at the beginning of the rachis. The genital apertures are retracted and there appears to be a single small pore without a flap.

The colourless jaw plates are 3 mm long and 1,5 mm wide. The platelets are up to 0,06 mm high. They are arranged in transverse, slightly slanting rows. Their surface is hexagonal. Near the anterior end they are about 0,034 by 0,018 mm (Fig. 13C), while posteriorly they are 0,046 by 0,018 mm (Fig. 13D).

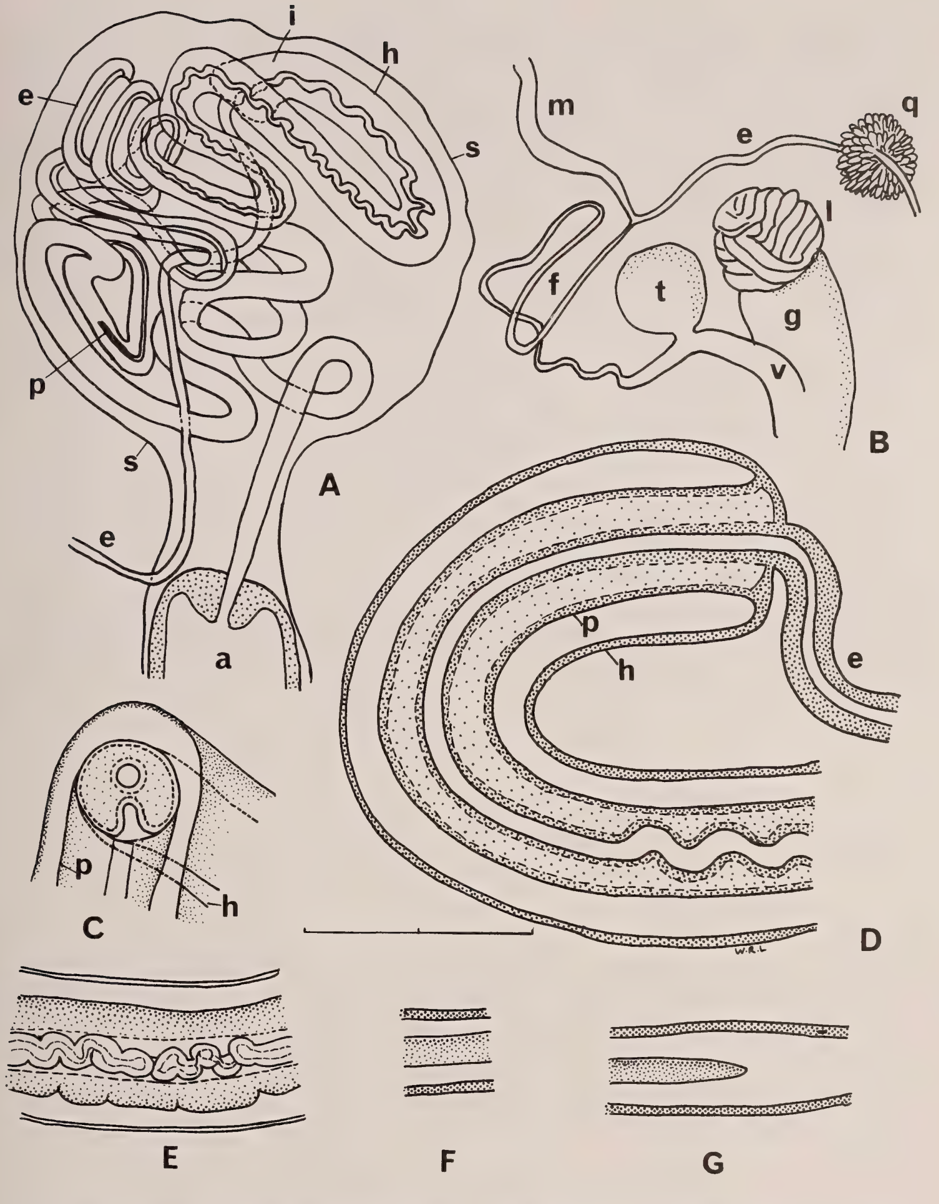

Fig. 14. *Pleurobranchaea bonnieae* sp. nov. A. Penial sac. B. Female organs. C. Optical transverse section of penis. D. Root of penis. E–G. Parts of penis in sheath, scale 0,2 mm.

The platelets bear nine to twelve denticles. The radula is 4,5 mm long and 2,4 mm wide. The largest of the light yellow, bicuspid teeth is 0,36 mm long. The formula is 35 × 55.0.55. About six of the outermost teeth are unicuspid. In the stomach was a 2 mm long aeolid nudibranch.

The reproductive organs were torn during preparation, but the male organ is complete. The globular penial sac is 1,2 mm in diameter, the atrium 1,6 mm long (Fig. 14A). A narrow efferent duct, 0,05 mm wide, traverses the penial sac and continues into the 0,14 mm wide penis proper. The penis is contained within a 0.25 mm wide penis sheath (Fig. 14D). For the first 1,4 mm of the looping penis the lumen is closely sinuous (Fig. 14E). Beyond this point the diameter of the penis diminishes to 0,07 mm while the sheath narrows to 0,12 mm in diameter (Fig. 14F). The 20 mm long organ is so tightly coiled that its further structure is not recognizable, except for the transverse section (Fig. 14C) and the tip of the penis (Fig. 14G). As a 0,082 mm wide tube the penis opens through a tiny papilla into the fundus of the atrium. On the basis of the structure of the penis and wide sheath around it we guess that the sheath is everted for copulation and the delicate, non-cuticular penis is protruded.

Discussion

While the single specimen may be juvenile, and the adult may have a cuticular penis, *P. bonnieae* can still be separated from all described members of the genus. *P. bonnieae* is most similar to *P. vayssierei* (Fig. 19B) and *P. notmec* (Fig. 18F), but differs by the wide base of the penis and in its shape in transverse section (Fig. 14C).

Pleurobranchaea bubala sp. nov.

Figs 15–17

Type material

Holotype: SAM–A35231, 1 specimen and egg mass, Buffels Bay at Cape Point, 10 m, collected by William R. Liltved, 4 October 1981.

Paratypes: SAM–A33966, one specimen, Simonstown harbour, Simon's Bay; SAM–A35232, 2 specimens, The Mill, Bakoven, Cape Peninsula, 20 m, collected by T. M. Gosliner, 16 September 1982.

Other material

SAM–A35233, 4 specimens, Inhaca, Mozambique, collected by W. Macnae.

Distribution

Specimens are known from the Atlantic coast of the Cape Peninsula to Inhaca, Mozambique.

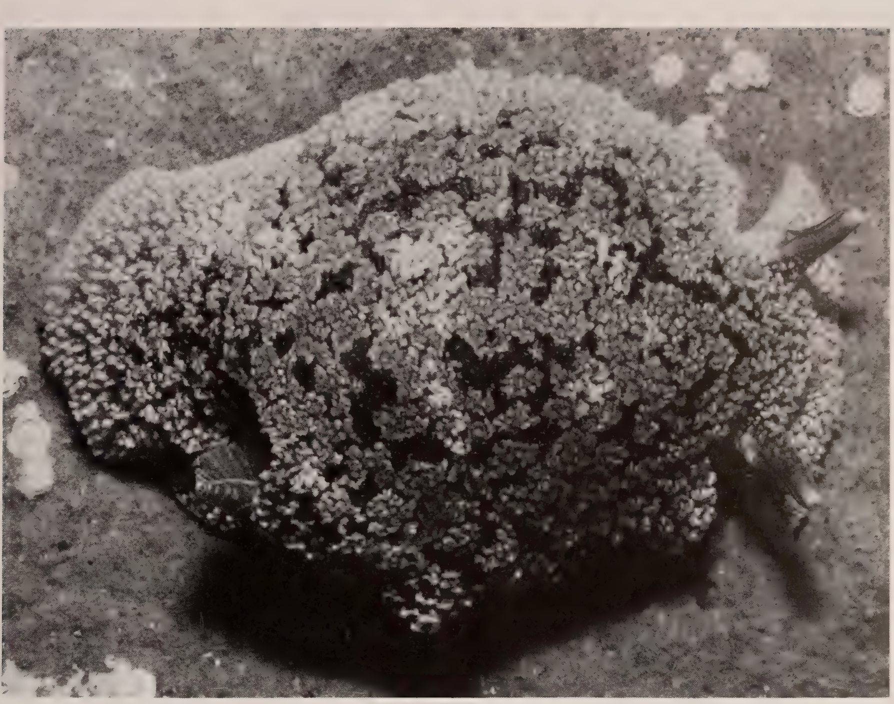

Fig. 15. *Pleurobranchaea bubala* sp. nov., living animal.

Etymology

This species is named *bubala* after the genus *Bubalus*, the buffalo, as it is common at Buffels Bay, Cape Point.

Description

One living animal (Fig. 15) was 70 mm in length. The notum has a pattern of dark brown pigment and irregular whitish blotches. A well-preserved animal measured 50 × 35 mm. Its notum extends over the foot on both sides (Fig. 16A–B). Posteriorly it gradually merges with the foot. The oral veil has a row of small tubercles. A spur is absent. A triangle of pedal glands was visible in one living specimen. The gill has a smooth rachis with twenty-six pinnae alternating on either side.

The hexagonal jaw platelets have four to fourteen denticles, rarely more than ten. The radula formula is 35 × 100.0.100; 20–30 of the outer laterals do not have a secondary cusp (Fig. 16D).

The genital apertures are protruded and have a slight flap on the hind border. The glandular tubes of the prostate are united, forming globular masses (Fig. 16G). The efferent duct between the prostate and penial sac is thick, 0,6 mm in diameter, its lumen is 0,2 mm in diameter. The penial sac (s)

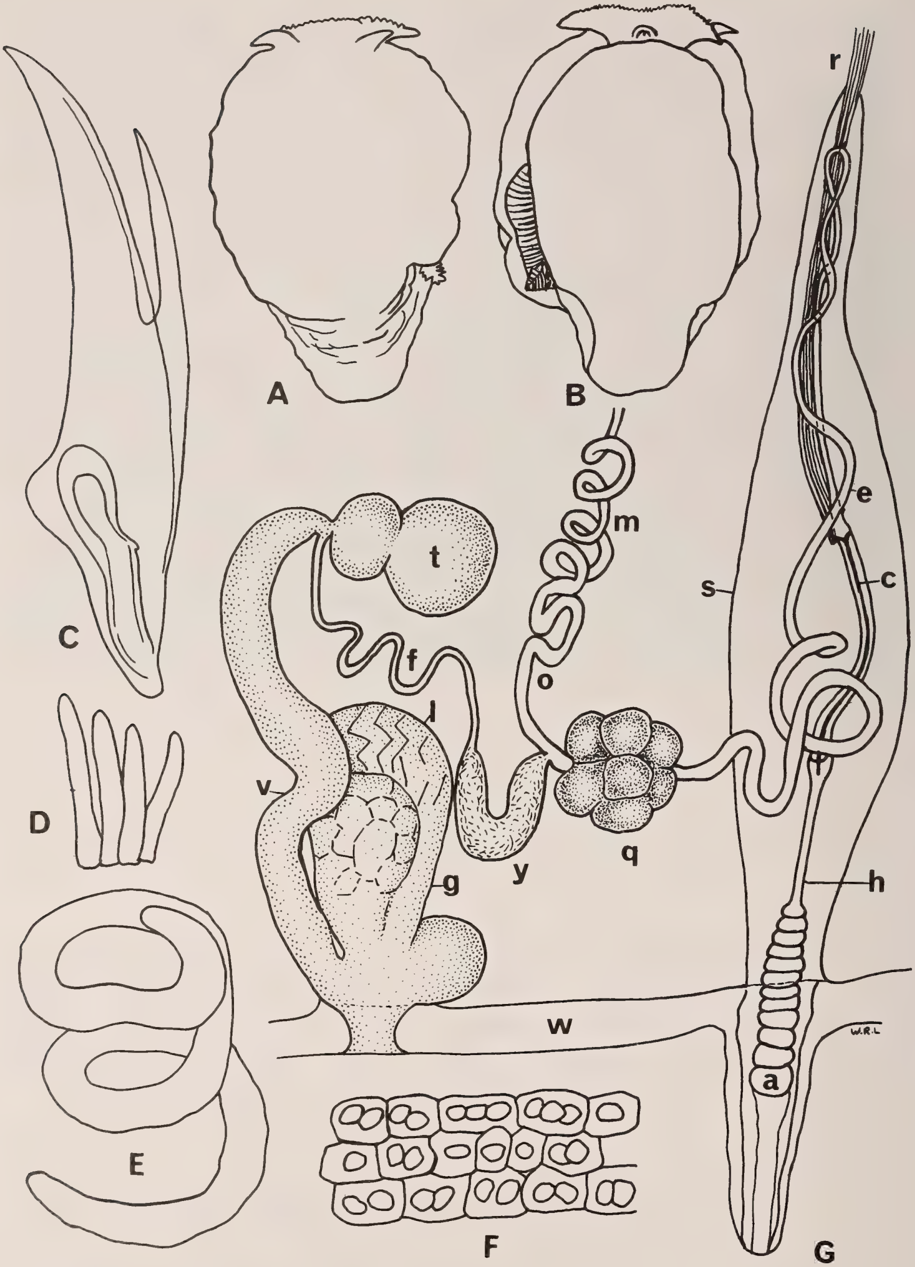

Fig. 16. *Pleurobranchaea bubala* sp. nov. A. Dorsal view of preserved animal. B. Ventral view of the same. C. Radular tooth from middle of half-row. D. Outermost teeth of row. E. Spawn. F. Eggs in spawn. G. Reproductive organs.

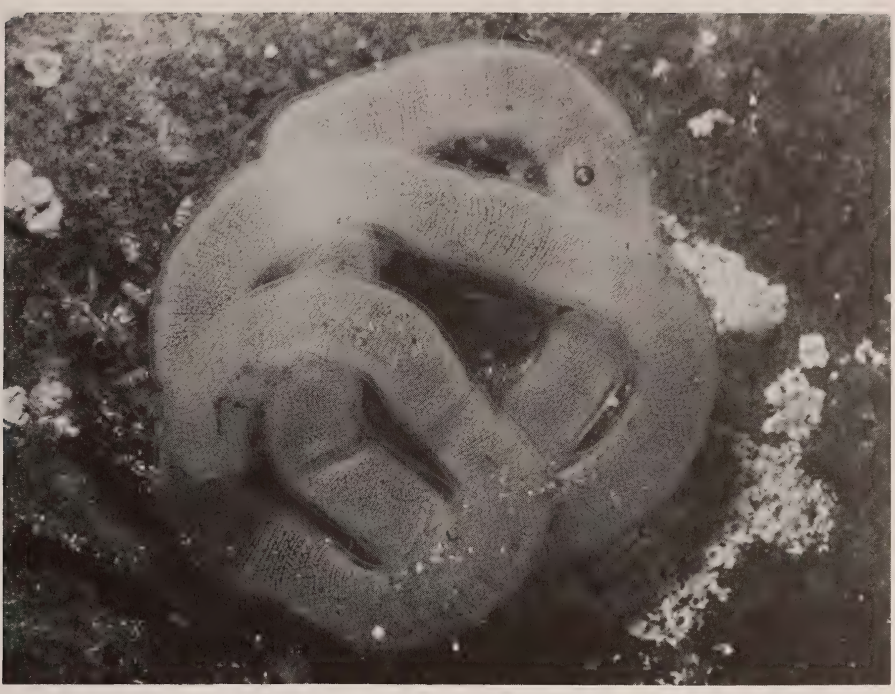

Fig. 17. *Pleurobranchaea bubala* sp. nov., egg mass.

accompanies the efferent duct (e) inward along the retractor muscle. It is wider in the middle than in *P. tarda*, but less globular than that of *P. inconspicua*. The cuticular stylet (c) is similar to that of *P. tarda* and about 5 mm in length. The atrium (a) is strongly muscular, 6–9 mm long.

The epithelium of the oviduct forms pouches, the spermatocyst (y). From the spermatocyst the oviduct narrows until it branches to the unstalked bilobed spermatheca (Fig. 16G). From this point the vagina (v) or insemination duct is much wider and has a high, folded epithelium. Near the female aperture it receives the accessory glands and forms a small caecum.

The egg mass (Figs 16E, 17) is a coiled tube of several irregular whorls. There are one to three eggs per capsule (Fig. 16F).

This species has been observed to feed on other opisthobranchs including members of its own species.

Discussion

The reproductive organs differ from the other species by the shape of the penial sac, the double spermatheca and the long glandular vagina. *P. bubala* is sympatric with *P. tarda* in South Africa and is distinguished by its larger size, abundant white blotches, elongate vagina, and the shape of the prostate (Figs 5A, 16G).

Pleurobranchaea notmec sp. nov.

Figs 1E–G, 18

Type material

Holotype: University of Israel, Department of Zoology 1005, eastern Mediterranean, off Turkey, 11–140 m.

Paratypes: University of Israel, Department of Zoology, two specimens, Haifa Bay; one specimen, Palmahim, 80 m; one specimen, No. 16399, northern Sinai, 45 m.

Etymology

The name refers to the fact that this species was originally identified as *P. meckelii*, from which it is distinct.

Description

The size of the preserved animals is from 12 to 40 mm long and 8 to 15 mm wide.

The surface of the mantle is slightly bossed, without tubercles.

The colour is not preserved, except some pigments in the furrows between the bosses. The animals are 'museum' brown. The notum is smaller than the foot. Its right border extends out over the gill. The anterior border of the notum forms the oral veil bearing a row of papillae. The sides of the veil are produced into pointed cephalic tentacles with split sides. The rhinophores are inserted between the tentacles and the lateral mantle border. They are as long as the tentacles, blunt, cylindrical, and rolled.

The anterior end of the foot is divided by a transverse furrow. The hind end bears a pointed dorsal spur. On the ventral side the pedal gland forms a longitudinal furrow.

The gill is about one-third of the body length and has twenty to thirty alternating pinnules on each side. Its anterior three-fourths to four-fifths are adnate. The anus is dorsal to the middle of the gill. The rachis is smooth.

The prebranchial glands open slightly anteriorly to the gill. A little more anteriorly are the genital apertures, united by a circular fold. Their shape varies according to contraction. A flap is absent. The large pharynx often protrudes from the mouth opening. The labial cuticle bears scattered papillae. The anterior border of the jaws appears whitish on the everted proboscis but is light brown when cleaned with potassium hydroxide. They are composed of columnar rodlets of variable shape, reaching 0,2 mm in height. The rodlets are polygonal, longer than wide. Ectally they measure about 0,05 mm in length and 0,04 mm in width. Posteriorly they are longer and narrower, the longest attaining 0,11 mm in length and 0,017 mm in width. Their frontal borders overlap and bear many small denticles, which are also present on the surface behind the border. The bases of the rodlets are more uniform in size. Anteriorly they are 0,05 by 0,03 mm; posteriorly 0,07 by 0,03 mm.

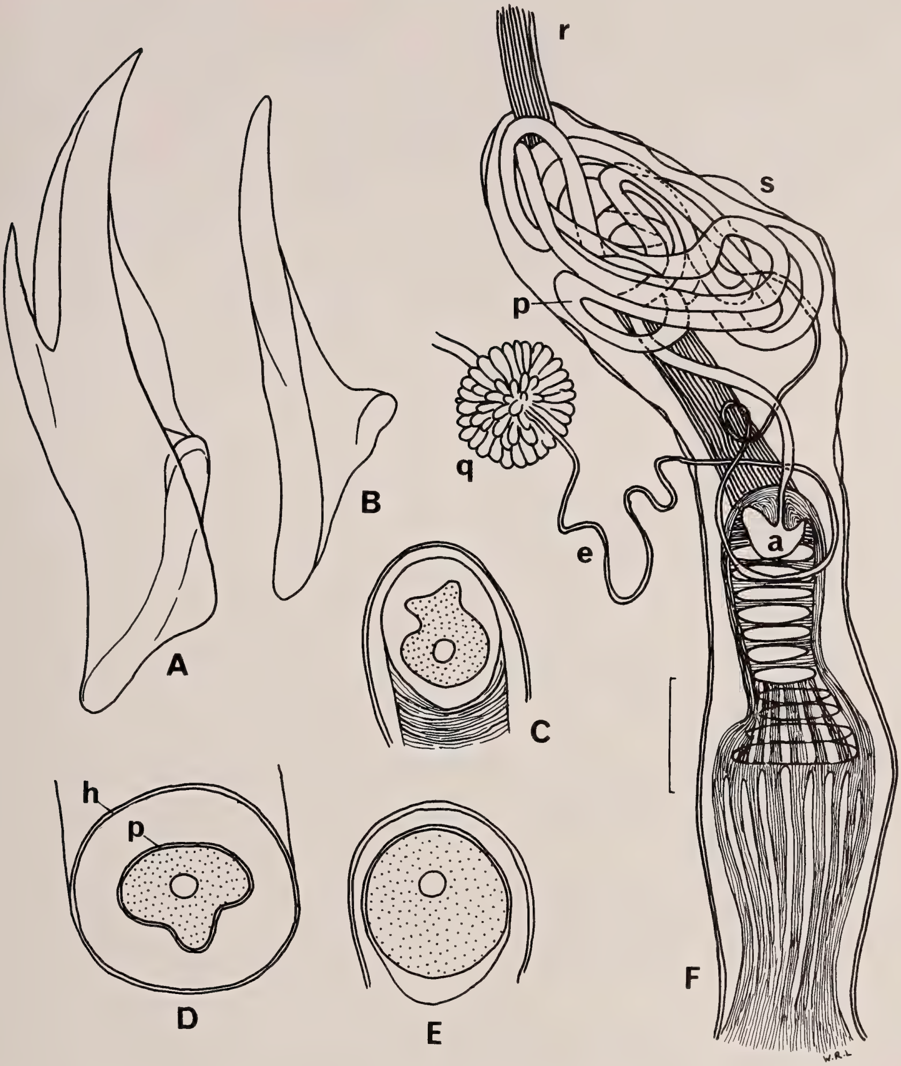

Fig. 18. *Pleurobranchaea notmec* sp. nov. A. Radular tooth from middle of half-row. B. Outer radular tooth. C–E. Optical sections of penis. F. Male reproductive organ, scale 0,3 mm.

The radula of the largest specimen is 16 mm long; each half is 5 mm broad. The formula is 50 × 80.0.80. The teeth have a small secondary cusp (Fig. 18A). In the middle of the half-row the longest teeth attain 0,65 mm in length and diminish gradually towards the outer edge. One to four outer teeth lack a secondary cusp (Fig. 18B).

The genital ducts are so compact that they could not be disentangled. The ovotestis follicles contain sperm or oocytes. The slender hermaphroditic duct widens into a long ampulla, narrows again, and divides into the male and female ducts. The male duct enters the round prostate (Fig. 18F, q) and emerges as a very thin efferent duct (e) which penetrates the penial sac (s) near its outer end. Inside the sac the penis is a long, winding tube, 0,17 mm in diameter. Its lumen is 0,10–0,14 mm in diameter. The penis has a very thin cuticle and is surrounded by a thin penial sheath (Fig. 18C–E), which must evidently be everted. After forming about six loops, the penis straightens and emerges in the male atrium as a small papilla (Fig. 18F). The atrium (a) is a wide, thick-walled sac that opens in front of the female pore.

It was not possible to follow the oviduct. It did not seem to have a spiralled spermatocyst.

Discussion

The present animals from Israel were originally identified as *Pleurobranchaea meckelii*. However, *P. meckelii* differs by its long whip-like, cuticular penial stylet. The single specimen of *P. vayssierei* (Fig. 19B) is also similar but lacks a cuticle around the efferent duct in the penial sheath.

Pleurobranchaea vayssierei sp. nov.

Fig. 19

Type material

Holotype: Museum National d'Histoire Naturelle, Paris, from Algiers, 1900, one specimen among Vayssière's specimens of *P. meckelii*, No. 52. (See p. 11.)

Etymology

The name refers to the fact that the unique specimen was found in the collection of Albert Vayssière.

Description

The preserved animal is 32 mm long, 11 mm broad and 10 mm high. The notum is as large as the foot, smooth and colourless. There is a tiny spur on the tip of the foot (Fig. 19A), and a weak metapodial gland on its underside. The oral veil is smooth, perhaps as a result of 82 years of preservation. The gill has a smooth rachis with twenty-six pinnae. The jaw plates (Fig. 19C) are broken. Their platelets are relatively broad (Fig. 19D). The platelets bear up to fifteen denticles, which disappeared after mounting them in glycerine. The radular formula is 35 × 65.0.65. The teeth are dark greyish and bicuspid (Fig. 19E). None are unicuspid on the outer border.

The male duct forms many loops in the tight transparent penial sac (Fig. 19B). A stylet is not recognizable. The single specimen was so fragile that the female organs could not be dissected completely. The spermatocyst is a slight

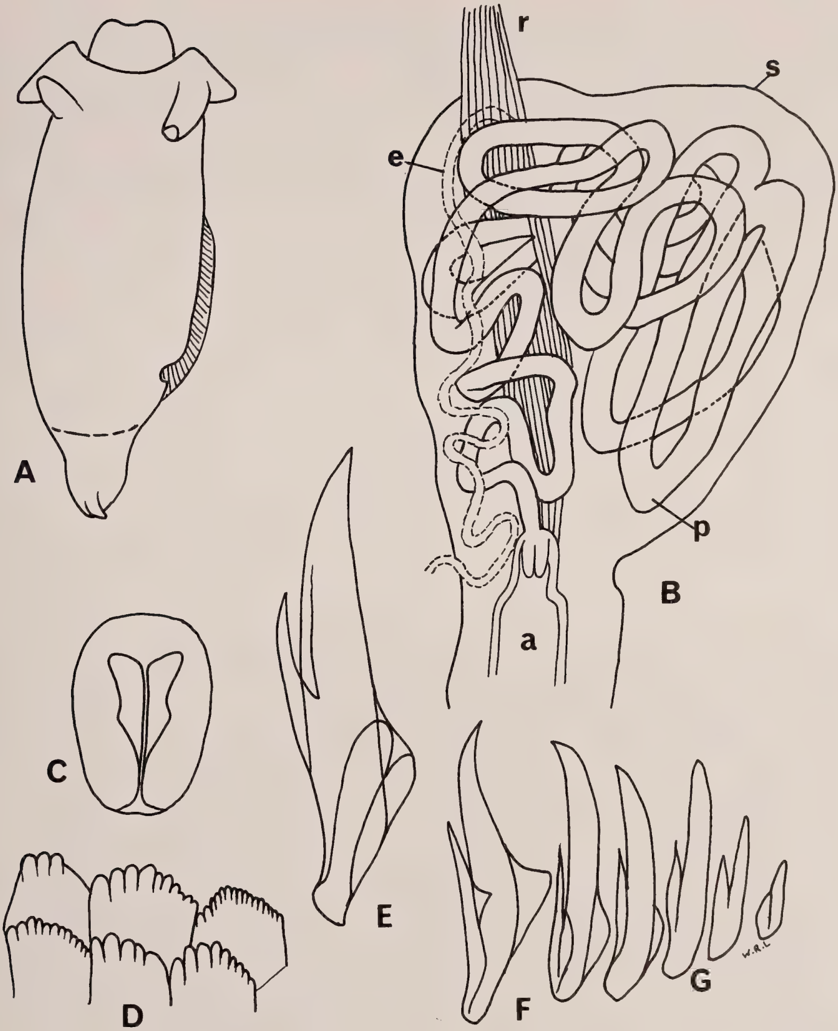

Fig. 19. *Pleurobranchaea vayssierei* sp. nov. A. Preserved specimen from Algiers. B. Penial sac. C. Anterior view of pharynx with jaws. D. Jaw platelets. E. Radular teeth from middle of half-row. F. Twenty-second outer tooth. G. Five outermost teeth.

widening of the oviduct, and the oviduct is continued into a long, rather narrow, ciliated vagina.

Discussion

The most similar species is *P. bonnieae* from Florida (Fig. 14A), which has an enlarged root of the penis. In *P. notmec* up to twenty teeth of the radula are unicuspid.

Pleurobranchaea (Macfarlandaea) subgen. nov.

Type species

Pleurobranchaea californica MacFarland, 1966.

Diagnosis

Pleurobranchaeidae with rudimentary secondary cusps on all radular teeth. Pleurembolic penis with cuticular stylet.

Etymology

The subgeneric name honours the late Frank Mace MacFarland of Stanford University.

Pleurobranchaea (Macfarlandaea) californica MacFarland, 1966

Figs 20–22

Pleurobranchaea californica MacFarland, 1966: 94–101, pl. 15 (figs 16–28), pl. 17 (figs 1–17). Chivers, 1967: 515–521.

Pleurobranchaea sp. Coan, 1964: 173.

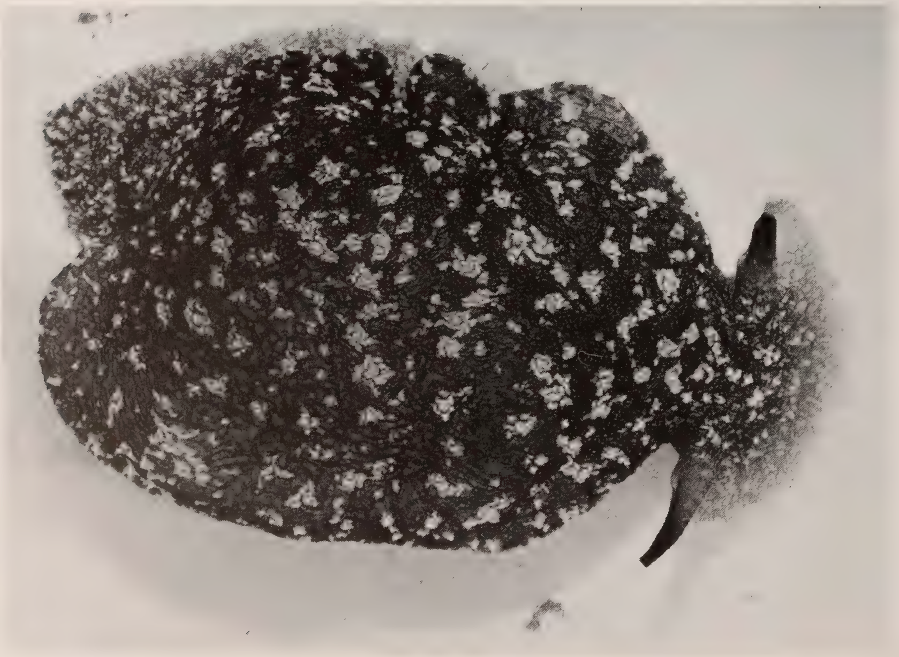

Fig. 20. *Pleurobranchaea (Macfarlandaea) californica* MacFarland, 1966, living animal.

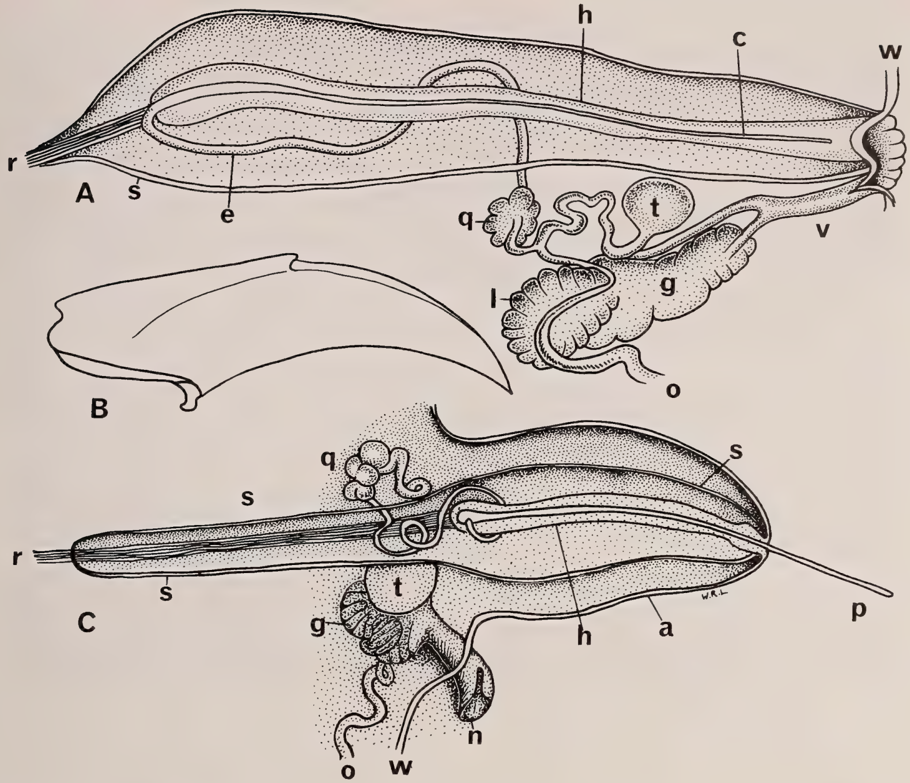

Fig. 21. *Pleurobranchaea (Macfarlandaea) californica* MacFarland, 1966 (after MacFarland 1966). A. Reproductive organs (retracted). B. Radular tooth. C. Reproductive organs with everted penis.

Distribution

California, from Klamath River to San Diego, 10–470 m.

Description

The living animal (Fig. 20) is brown with white blotches, up to 335 mm long. The rhinophores are typical of the family Pleurobranchaeidae. The jaw platelets are columnar with denticles. The radular formula of a 165 mm long animal is 52 × 130–145.1.130–145. All the lateral teeth have a rudimentary secondary cusp (MacFarland 1966: pl. 15 (figs 22–24)). The penis sac (= penis sheath, MacFarland 1966) is long (2 cm in an adult specimen) and not quite close around the penial sheath (= preputium, MacFarland 1966). The efferent duct accompanies the retractor muscle upwards and they enter the sheath together. Here the sheath separates from the whip-like muscular penis. The egg mass is a highly convoluted collar (Fig. 22).

Coan (1964: 173) observed that the species is carnivorous and cannibalistic.

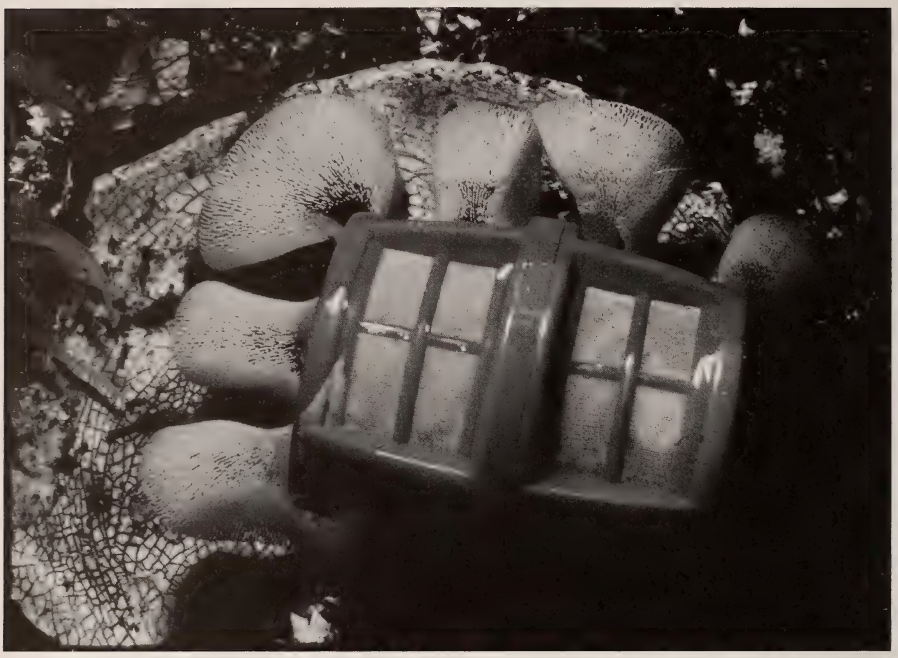

Fig. 22. *Pleurobranchaea (Macfarlandaea) californica* MacFarland, 1966. Egg mass.

Euselenops Pilsbry, 1896

Pleurobranchaea (Euselenops) Pilsbry, 1896: 228. Thiele 1931: 419.
Neda Adams & Adams, 1854. *Non* Mulsant.
Oscaniopsis Bergh, 1897: 53. Vayssière, 1901: 6.

Type species

Pleurobranchus luniceps Cuvier, 1817.

Diagnosis

Notum much smaller than foot, penis papillate.

Euselenops luniceps (Cuvier, 1817)

Fig. 25D–G

Pleurobranchus luniceps Cuvier, 1817: 186.
Oscaniopsis semperi Bergh, 1897: 55, pl. 6 (figs 7–27).
Oscaniopsis compta Bergh, 1897: 58, pl. 8 (figs 11–27).
Oscaniopsis amboinei Vayssière, 1898: 9, fig. 27; 1901: 15, figs 190–204.
Non Oscaniopsis pleurobranchaeana Bergh, 1907: 35, pl. 4 (figs 16–21).
Oscaniopsis luniceps Vayssière, 1901: 15.
Euselenops luniceps O'Donoghue, 1929: 55, figs 65–74. Pruvot-Fol, 1933: 107. Burn, 1962: 131. Lin Guangyu & Tchang-Si, 1965: 269, 275, fig. 4.

Distribution

Indo-Pacific: Hawaii, China, Hong Kong, Hainan, Japan, Philippines, Amboina, Queensland, Mauritius, Inhaca, South Africa, ?Red Sea.

Description

The length is up to 90 mm (Lin Guangyu & Tchang Si 1965) with the notum much smaller than the foot and its hind end forming a projecting tip. The radular teeth are unicuspid. The prostatic cells are contained in the efferent duct and the acrembolic penis is covered with soft cones.

Discussion

One 12 mm long specimen from Palmahim, Israel, had the outer aspect of *Euselenops* with a broad velum, small notum, large foot, and a notch in the hind end of the mantle. At first glance it seemed to be a *Euselenops* sp., but it was discovered that the radula was bicuspid, that the notal notch was the siphon of the gill, and that there was a large spur on the tip of the foot (Fig. 25B), indicating that it was a *Pleurobranchaea* sp. As the reproductive organs were not developed, the species could not be determined.

Pleurobranchella Thiele, 1925

Pleurobranchella Thiele, 1925: 283. Willan, 1977: 151.
Pleurobranchoides O'Donoghue, 1929: 62.
Pleurobranchaea (Euselenops) Pleurobranchella Thiele, 1931: 419.

Type species

Pleurobranchella nicobarica Thiele, 1925.

Diagnosis

Unicuspid species of Pleurobranchaeidae; notum covering foot on all sides; acrembolic penis with cuticular hooks.

Pleurobranchella nicobarica Thiele, 1925

Figs 23–24

Pleurobranchella nicobarica Thiele, 1925: 283, pl. 33 (figs 9–11).
Pleurobranchoides gilchristi O'Donoghue, 1929: 62, figs 75–85. Eales, 1937: 371.
Pleurobranchoides sp. Eales, 1938: 90, fig. 10.

Material

SAM–A33973, three specimens (105 mm, 115 mm, 150 mm long, preserved), Monte Belo, Mozambique, 400 m.

Distribution

Nicobares, Gulf of Aden, southern Africa, 220–269 m.

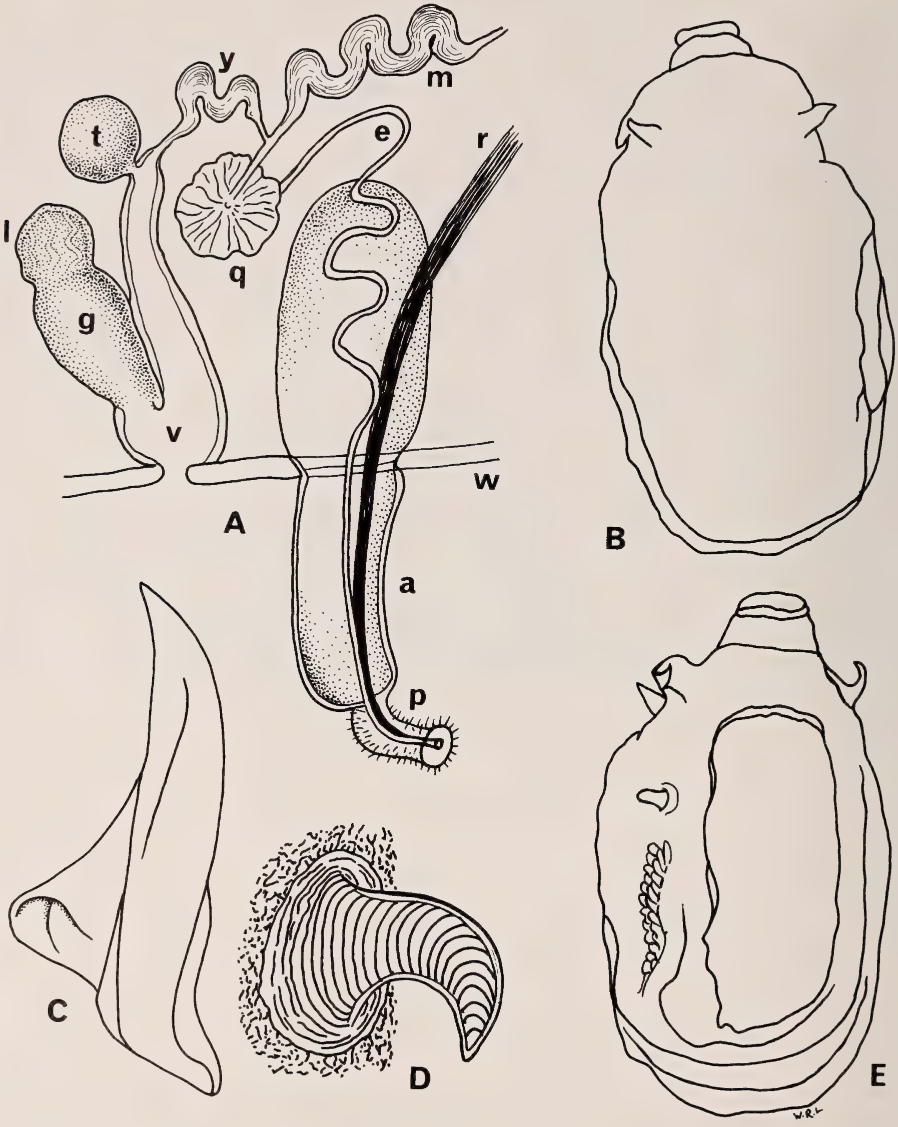

Fig. 23. *Pleurobranchella nicobarica* Thiele, 1925. A. Diagram of reproductive organs. B. Dorsal aspect. C. Radular tooth. D. Penial hook, scale 100 μm. E. Ventral aspect.

Description

The large mantle extends far over the foot on all sides (Fig. 23E). The radular formula is 60 × 133.0.133. The extruded penis (Fig. 24B) consists of a wide everted atrium and a long cylindrical, slightly spiralled penis proper. Its concave

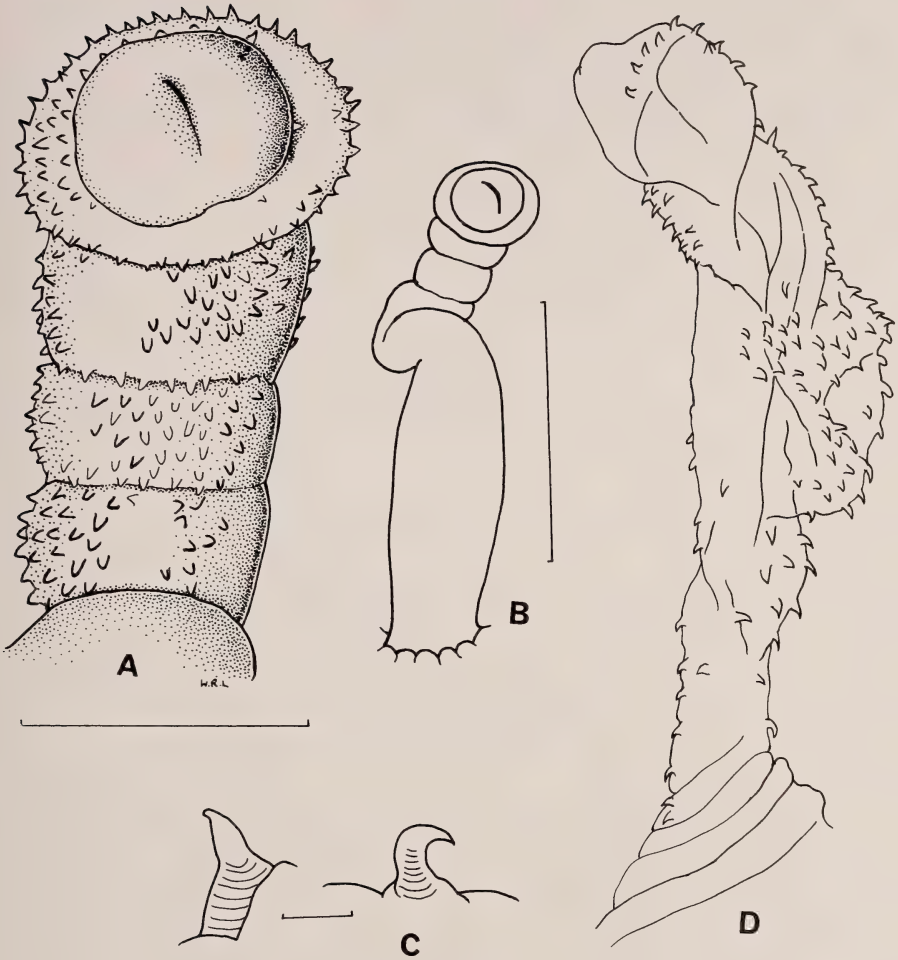

Fig. 24. *Pleurobranchella nicobarica* Thiele, 1925. A. Outer end of penis, scale 2,0 mm. B. Extruded penis, scale 5,0 mm. C. Penial hooks. D. Penis removed from retracted sac.

side is smooth; the convex side is covered with hook-shaped papillae (Fig. 24C–D). The extruded atrium is 30 mm long and 8 mm wide in the largest specimen. The penis proper is 7 by 2 mm in the largest specimen and 6 by 2,5 mm in the smallest.

Discussion

Though Thiele (1925) did not figure the penis of his *Pleurobranchella nicobarica*, his description is precise enough to identify the present specimens with his material. O'Donoghue gave only a short description of *Pleurobranchoides* *gilchristi*, but it is considered sufficient to synonymize it with *Pleurobranchella nicobarica*.

Eales's (1938: 90, fig. 10) *Pleurobranchoides* sp. from the Gulf of Aden has a papillate penis and is certainly identical with *Pleurobranchella nicobarica*.

Koonsia Verrill, 1882

Koonsia Verrill, 1882: 545.

Type species

Koonsia obesa Verrill, 1882.

Remarks

Pilsbry (1896: 221) considered *Pleurobranchillus* Bergh, 1892, as a synonym of *Koonsia*, but Bergh (1897) transferred *Pleurobranchillus* to *Pleurobranchaea*, as did Willan (1977: 153).

Koonsia obesa Verrill, 1882

Fig. 25C

Koonsia obesa Verrill, 1882: 545, *partim*; 1884: pl. 28 (fig. 7); 1885: 571, fig. 107. Abbott, 1974: 349, fig. 2046.

Distribution

Western Atlantic, ?Martha's Vineyard: ?Delaware Bay, 400–560 m.

Discussion

Verrill (1882) included two distinct species in his original description. In his description of the genus Verrill (1882: 545) stated that 'the back is overhanging both on the sides and posteriorly, and there is a distinct mantle edge all around'. This agrees with the species description that 'the mantle forms a ring along the lateral and posterior borders'; it does not correspond to the figure of *Koonsia obesa* but to his distinct paratypes, which have been examined (see *P. confusa*). He stated that 'the foot is narrower', as in the paratype. In the generic diagnosis Verrill stated that 'the verge is armed with small hooks, but the spicule, present in *Pleurobranchaea*, is not protruded in any of our specimens of *Koonsia*, if present'. He neglected to mention this in the species description, but noted of *Pleurobranchaea tarda* 'the verge . . . with rows of minute recurved hooks near the end, and terminated by a slender, curved spicule' (Verrill 1882: 546).

The paratypes without hooks seen by Bergh (1897), Vayssière (1901), and the authors (Fig. 3) are quite different from Verrill's figure (1885: 107). They also differ from his figures of *P. tarda* (1882, pl. 58 (fig. 6); 1885, fig. 105), which possess a stylet, but lack hooks.

As Bergh (1897: 33) did not find penial hooks in the paratype specimen of '*Koonsia obesa*' from the original locality, he rejected *Koonsia* and placed *K. obesa* in *Pleurobranchaea*. The authors believe that the distinct penial spines

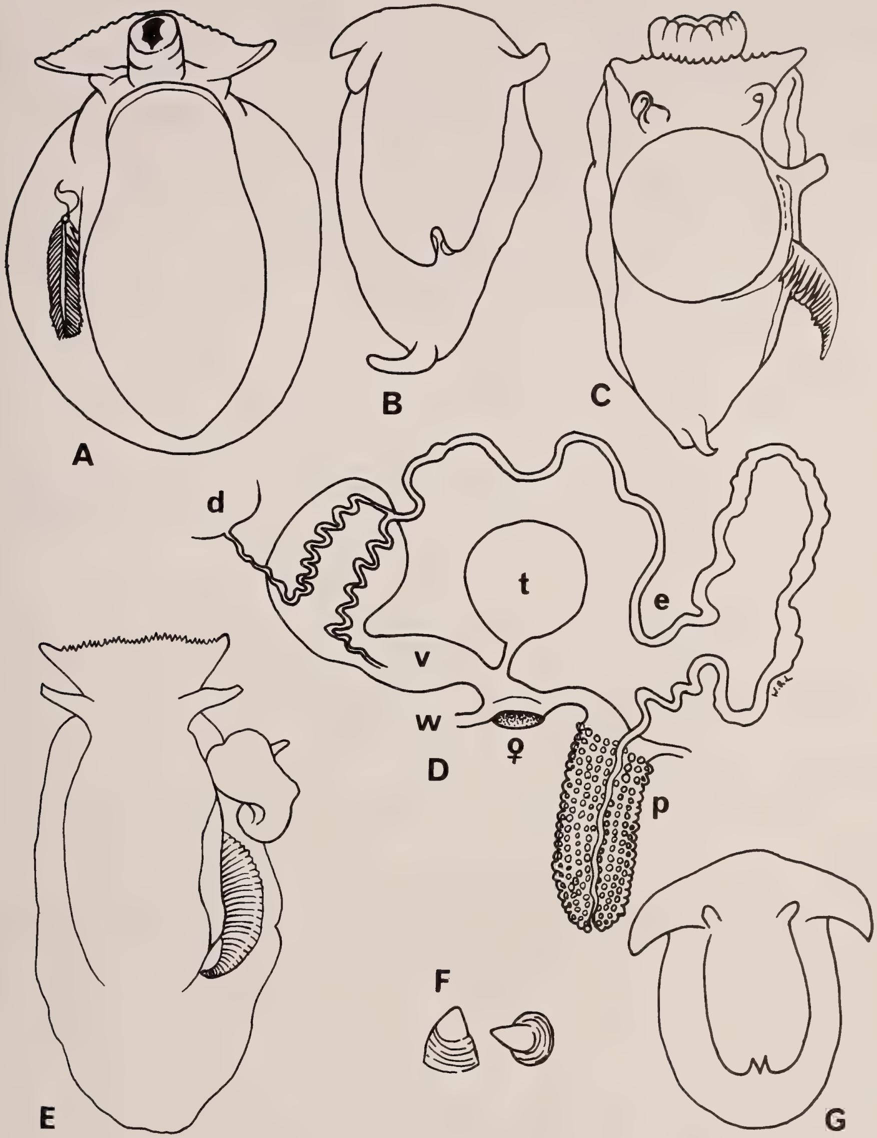

Fig. 25. A. *Gigantonotum album* Lin Guangyu & Tchang Si, 1965, preserved specimen (after Lin Guangyu & Tchang Si 1965). B. Juvenile *Pleurobranchaea* sp. from Israel. C. *Koonsia obesa* Verrill, 1882, holotype (after Verrill 1882). D. *Euselenops luniceps* (Cuvier, 1817) reproductive system (after Vayssière 1901). E. *Pleurobranchaea maculata* (Quoy & Gaimard, 1832), preserved specimen (after Baba 1937). F–G. *Euselenops luniceps*. F. Penial papillae (after Bergh 1897). G. Whole animal (after Lin Guangyu & Tchang Si 1965).

described by Verrill indicate that his type material actually represents two species and therefore name the paratype examined *Pleurobranchaea confusa*. If the slender species (Fig. 25C) is found again, its generic placement depends upon whether the radula is unicuspid or bicuspid. Until such time it is preferred to maintain *Koonsia* as a distinct genus. *Pleurobranchella nicobarica* Thiele, 1925, *Euselenops luniceps* (Cuvier, 1817), and *Pleurobranchus hirasei* Baba, 1971, are the only other notaspideans known to possess an ornamented penis.

Gigantonotum Lin Guangyu & Tchang Si, 1965

Gigantonotum Lin Guangyu & Tchang Si, 1965: 270.

Type species

Gigantonotum album Lin Guangyu & Tchang Si, 1965.

Diagnosis

Pleurobranchaeid with a very wide mantle that covers the foot and the gill completely. Its borders are almost half as wide as the foot. Its underside bears nodules. The radula is unicuspid; its formula is 52 × 144.1.144.

Gigantonotum album Lin Guangyu & Tchang Si, 1965

Fig. 25A

Gigantonotum album Lin Guangyu and Tchang Si, 1965: 270, figs 5–6, pl. 1 (fig. 5d, v).
Pleurobranchella alba Willan, 1977: 153.

Distribution

South of Hainan Island, China Sea, 220 m.

Discussion

Lin Guangyu & Tchang Si (1965) compared their species with *Koonsia*, but stated that in *Gigantonotum* the foot is covered by the mantle, while it extends posteriorly for a considerable distance in *Koonsia*.

On the whole, *Gigantonotum* is similar to *Pleurobranchella* which, however, lacks a rachidian tooth. The geographic proximity makes a synonymy probable. Willan (1977: 151) synonymized *Gigantonotum* with *Pleurobranchella*, but considered only the incomplete previous descriptions. As long as the reproductive organs of *G. album* remain unknown it is preferable to consider *Gigantonotum* as a distinct but doubtful genus.

ZOOGEOGRAPHY OF THE PLEUROBRANCHAEIDAE

Only preliminary zoogeographical remarks can be made, owing to the fact that many records are based on unrecognizable, incompletely described, or unjustly synonymized species. In other cases information about the fauna of a region is incomplete. For example, Edmunds (1977) did not record any notaspideans from Ghana.

Five species of Pleurobranchaeidae have been recorded from the western Atlantic: *Pleurobranchaea tarda, P. agassizii, P. inconspicua, P. bonnieae*, and *Koonsia obesa*. Of these, *P. tarda* and *P. inconspicua* are more widespread. *P. tarda* is known from the eastern Atlantic coast of Africa from Ghana and from South Africa, where it extends into the Indian Ocean. *P. inconspicua* is also known from the Mediterranean and west Africa. *Pleurobranchaea meckelii, P. notmec* and *P. vayssierei* are known only from the Mediterranean, while *P. augusta* has been recorded only from west Africa. *P. bubala* is known from the Atlantic and Indian Ocean coasts of southern Africa.

Pleurobranchaea brockii and *Pleurobranchella nicobarica* are both known from the eastern and western Indian Ocean. *Euselenops luniceps* is widespread in the Indo-Pacific where it has been recorded from Hawaii to South Africa. Other species known from the Indo-Pacific region—*Pleurobranchaea maculata* and *Gigantonotum album*—may be widespread but their ranges need to be established from reliable records.

Pleurobranchaea californica is restricted to the Pacific coast of North America.

ACKNOWLEDGEMENTS

We are deeply indebted to our colleagues at other institutions who generously provided assistance and specimens. To Frederick M. Bayer, Harald Rehder, and Joseph Rosewater of the United States National Museum, Washington; Alexander Barash, University of Israel, Tel Aviv; Hanne Just, Zoology Museum, Copenhagen; Philippe Bouchet, Museum National d'Histoire Naturelle, Paris; and Luise Schmekel, Zoologisches Institut der Universität, Münster, we extend our sincere thanks.

Several staff members of the South African Museum provided considerable assistance. William Liltved prepared the final figures and collected specimens. Michelle van der Merwe printed the photographs and Marcelle Scheiner typed the final drafts of the manuscript. To them we also extend our appreciation.

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ABBREVIATIONS

a	atrium
b	base of penis
c	penial stylet
d	hermaphrodite duct
e	efferent duct
f	oviduct
g	mucous gland
h	penial sheath
i	root of penis
j	rhinophore
k	gill
l	albumen gland
m	ampulla
n	female pore
o	spermoviduct
p	penis
q	prostate
r	retractor muscle
s	penial sac
t	spermatheca
v	vagina
w	body wall
x	spur
y	spermatocyst
z	foot gland
♀	female gonopore
♂	male gonopore

6. SYSTEMATIC papers must conform to the *International code of zoological nomenclature* (particularly Articles 22 and 51).

Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family Nuculanidae

Nuculana (Lembulus) bicuspidata (Gould, 1845)

Figs 14–15A

Nucula (Leda) bicuspidata Gould, 1845: 37.
Leda plicifera A. Adams, 1856: 50.
Laeda bicuspidata Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).
Nucula largillierti Philippi, 1861: 87.
Leda bicuspidata: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:
comma separates author's name and year
semicolon separates more than one reference by the same author
full stop separates references by different authors
figures of plates are enclosed in parentheses to distinguish them from text-figures
dash, not comma, separates consecutive numbers

Synonymy arrangement according to chronology of bibliographic references, whereby the year is placed in front of each entry, and the synonym repeated in full for each entry, is not acceptable.

In describing new species, one specimen must be designated as the holotype; other specimens mentioned in the original description are to be designated paratypes; additional material not regarded as paratypes should be listed separately. The complete data (registration number, depository, description of specimen, locality, collector, date) of the holotype and paratypes must be recorded, e.g.:

Holotype

SAM–A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach Port Elizabeth (33°51′S 25°39′E), collected by A. Smith, 15 January 1973.

Note standard form of writing South African Museum registration numbers and date.

7. SPECIAL HOUSE RULES

Capital initial letters

(a) The Figures, Maps and Tables of the paper when referred to in the text
e.g. '. . . the Figure depicting *C. namacolus* . . .'; '. . . in *C. namacolus* (Fig. 10) . . .'

(b) The prefixes of prefixed surnames in all languages, when used in the text, if not preceded by initials or full names
e.g. Du Toit but A. L. du Toit; Von Huene but F. von Huene

(c) Scientific names, but not their vernacular derivatives
e.g. Therocephalia, but therocephalian

Punctuation should be loose, omitting all not strictly necessary

Reference to the author should be expressed in the third person

Roman numerals should be converted to arabic, except when forming part of the title of a book or article, such as
'Revision of the Crustacea. Part VIII. The Amphipoda.'

Specific name must not stand alone, but be preceded by the generic name or its abbreviation to initial capital letter, provided the same generic name is used consecutively.

Name of new genus or species is not to be included in the title: it should be included in the abstract, counter to Recommendation 23 of the Code, to meet the requirements of Biological Abstracts.

EVELINE d. B.-R. MARCUS
&
TERRENCE M. GOSLINER

REVIEW OF THE FAMILY PLEUROBRANCHAEIDAE (MOLLUSCA, OPISTHOBRANCHIA)

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UME 93 PART 2 FEBRUARY 1984

ISSN 0303-2515

ANNALS
OF THE SOUTH AFRICAN MUSEUM

CAPE TOWN

INSTRUCTIONS TO AUTHORS

1. MATERIAL should be original and not published elsewhere, in whole or in part.

2. LAYOUT should be as follows:

(a) *Centred masthead to consist of*
Title: informative but concise, without abbreviations and not including the names of new genera or species
Author's(s') name(s)
Address(es) of author(s) (institution where work was carried out)
Number of illustrations (figures, enumerated maps and tables, in this order)
(b) *Abstract* of not more than 200 words, intelligible to the reader without reference to the text
(c) *Table of contents* giving hierarchy of headings and subheadings
(d) *Introduction*
(e) *Subject-matter* of the paper, divided into sections to correspond with those given in table of contents
(f) *Summary*, if paper is lengthy
(g) *Acknowledgements*
(h) *References*
(i) *Abbreviations*, where these are numerous

3. MANUSCRIPT, to be submitted in triplicate, should be typewritten and neat, double spaced with 2,5 cm margins all round. First lines of paragraphs should be indented. Tables and a list of legends for illustrations should be typed separately, their positions indicated in the text. All pages should be numbered consecutively.

Major headings of the paper are centred capitals; first subheadings are shouldered small capitals; second subheadings are shouldered italics; third subheadings are indented, shouldered italics. Further subdivisions should be avoided, as also enumeration (never roman numerals) of headings and abbreviations.

Footnotes should be avoided unless they are short and essential.

Only generic and specific names should be underlined to indicate italics; all other marking up should be left to editor and publisher.

4. ILLUSTRATIONS should be reducible to a size not exceeding 12 × 18 cm (19 cm including legend); the reduction or enlargement required should be indicated; originals larger than 35 × 47 cm should not be submitted; photographs should be rectangular in shape and final size. A metric scale should appear with all illustrations, otherwise magnification or reduction should be given in the legend; if the latter, then the final reduction or enlargement should be taken into consideration.

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The number of the figure should be lightly marked in pencil on the back of each illustration.

5. REFERENCES cited in text and synonymies should all be included in the list at the end of the paper, using the Harvard System (*ibid.*, *idem*, *loc. cit.*, *op. cit.* are not acceptable):

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'Smith (1969) describes . . .'
'Smith (1969: 36, fig. 16) describes . . .'
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For books give title in italics, edition, volume number, place of publication, publisher.
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Fischer, P.-H., Duval, M. & Raffy, A. 1933. Études sur les échanges respiratoires des littorines. *Archs Zool. exp. gén.* **74**: 627–634.
Kohn, A. J. 1960*a*. Ecological notes on *Conus* (Mollusca: Gastropoda) in the Trincomalee region of Ceylon. *Ann. Mag. nat. Hist.* (13) **2**: 309–320.
Kohn, A. J. 1960*b*. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bull. Bingham oceanogr. Coll.* **17** (4): 1–51.
Thiele, J. 1910. Mollusca: B. Polyplacophora, Gastropoda marina, Bivalvia. *In:* Schultze, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika* **4**: 269–270. Jena: Fischer. *Denkschr. med.-naturw. Ges. Jena* **16**: 269–270.

(continued inside back cover)

ANNALS OF THE SOUTH AFRICAN MUSEUM
ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

Volume **93** Band
February **1984** Februarie
Part **2** Deel

THE SOUTH AFRICAN MUSEUM'S *MEIRING NAUDE* CRUISES
PART 14
FAMILY MYCTOPHIDAE (OSTEICHTHYES, MYCTOPHIFORMES)

By

P. ALEXANDER HULLEY

Cape Town Kaapstad

The ANNALS OF THE SOUTH AFRICAN MUSEUM

are issued in parts at irregular intervals as material
becomes available

Obtainable from the South African Museum, P.O. Box 61, Cape Town 8000

Die ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

word uitgegee in dele op ongereelde tye na gelang van die
beskikbaarheid van stof

Verkrygbaar van die Suid-Afrikaanse Museum, Posbus 61, Kaapstad 8000

OUT OF PRINT/UIT DRUK
1, 2(1–3, 5–8), 3(1–2, 4–5, 8, t.–p.i.), 5(1–3, 5, 7–9),
6(1, t.–p.i.). 7(1–4), 8, 9(1–2, 7), 10(1–3),
11(1–2, 5, 7, t.–p.i.), 15(4–5), 24(2), 27, 31(1–3), 32(5), 33, 36(2), 45(1)

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Kopieregnavrae aan die Suid-Afrikaanse Museum

ISBN 0 86813 052 4

Printed in South Africa by
The Rustica Press, Pty., Ltd.,
Court Road, Wynberg, Cape

In Suid-Afrika gedruk deur
Die Rustica-pers, Edms., Bpk.,
Courtweg, Wynberg, Kaap

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PART 14

FAMILY MYCTOPHIDAE (OSTEICHTHYES, MYCTOPHIFORMES)

By

P. ALEXANDER HULLEY

South African Museum, Cape Town

(With 19 figures)

[*MS accepted 19 July 1983*]

ABSTRACT

Fifty-seven species of Myctophidae (Osteichthyes, Myctophiformes) are recorded from off the east coast of South Africa. No new species are described; thirteen species are recorded for the first time in the southern African region. The Myctophidae include both mesopelagic and bathypelagic high-oceanic species, and pelagic pseudoceanic species.

CONTENTS

PAGE

Introduction ... 53
Species list ... 56
Systematic account ... 66
Discussion ... 92
Acknowledgements ... 94
References ... 94

INTRODUCTION

From 1975 to 1979, the Department of Marine Biology, South African Museum, undertook a series of sampling cruises off the east coast of southern Africa in order to investigate the deep benthic fauna (at depths greater than 500 m) and the mesopelagic fauna of that region. This paper deals with the lantern-fishes (Family Myctophidae), comprising some 800 specimens, obtained during the five cruises. The stations occupied are given in Figures 1 and 2. Station data have been given by Louw (1977, 1980), so that the reader should refer to these publications for details.

Genera and species are arranged alphabetically for easier reference both in the *Species list* and in the *Systematic account* but, in the latter case, only the species that are recorded for the first time in the southern African region (the area between 20°S and 40°S and from 10°E to 40°E) or problematic species are described. For these, synonymies include references to type specimens (with type localities given in parentheses) and references pertinent to the southern African region. Where relevant, remarks are made on other species.

Ann. S. Afr. Mus. **93** (2), 1984: 53–96, 19 figs.

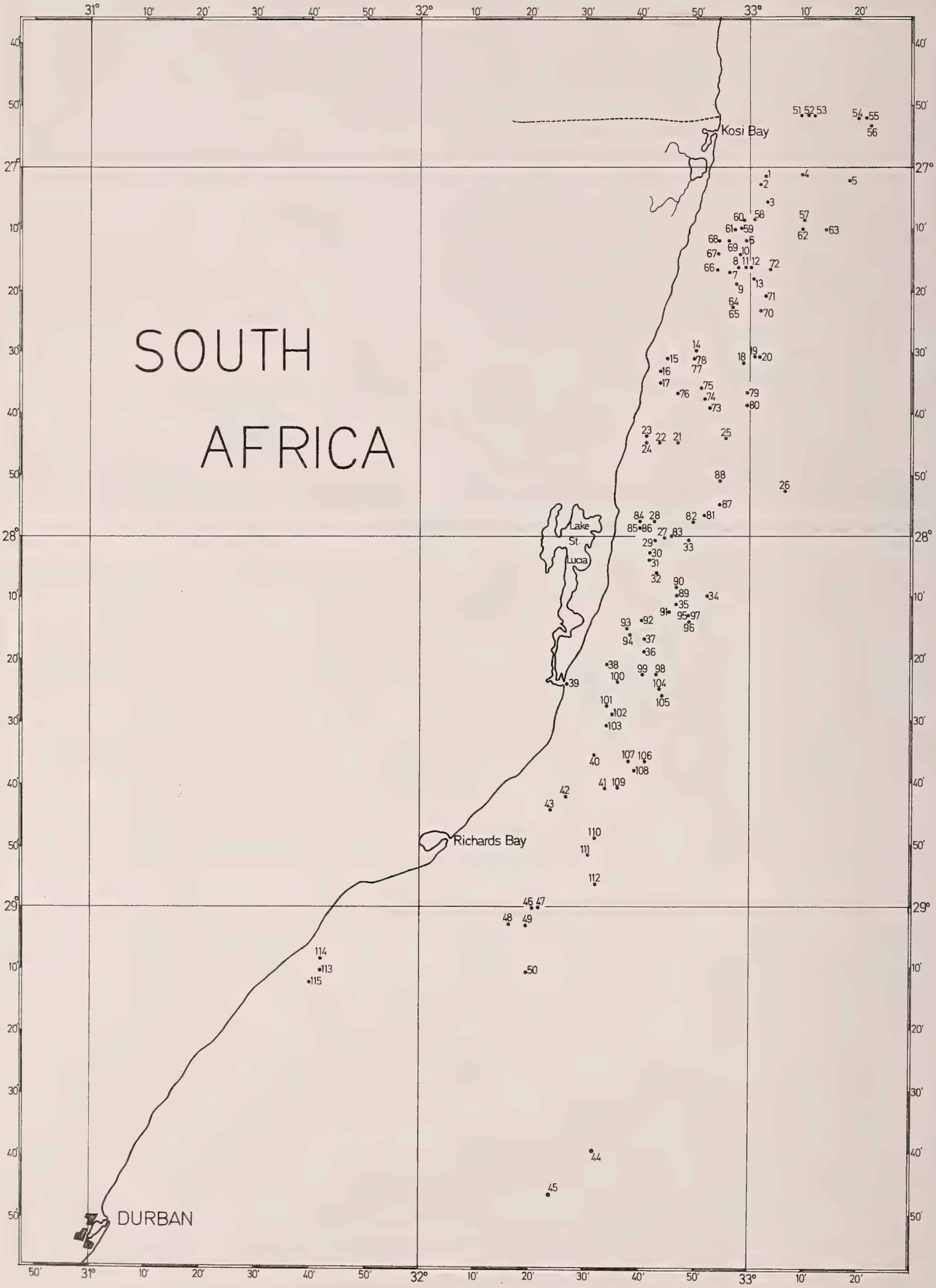

Fig. 1. Stations occupied off the east coast of South Africa, north of Durban, during the cruises of the South African Museum on the R.V. *Meiring Naude*.

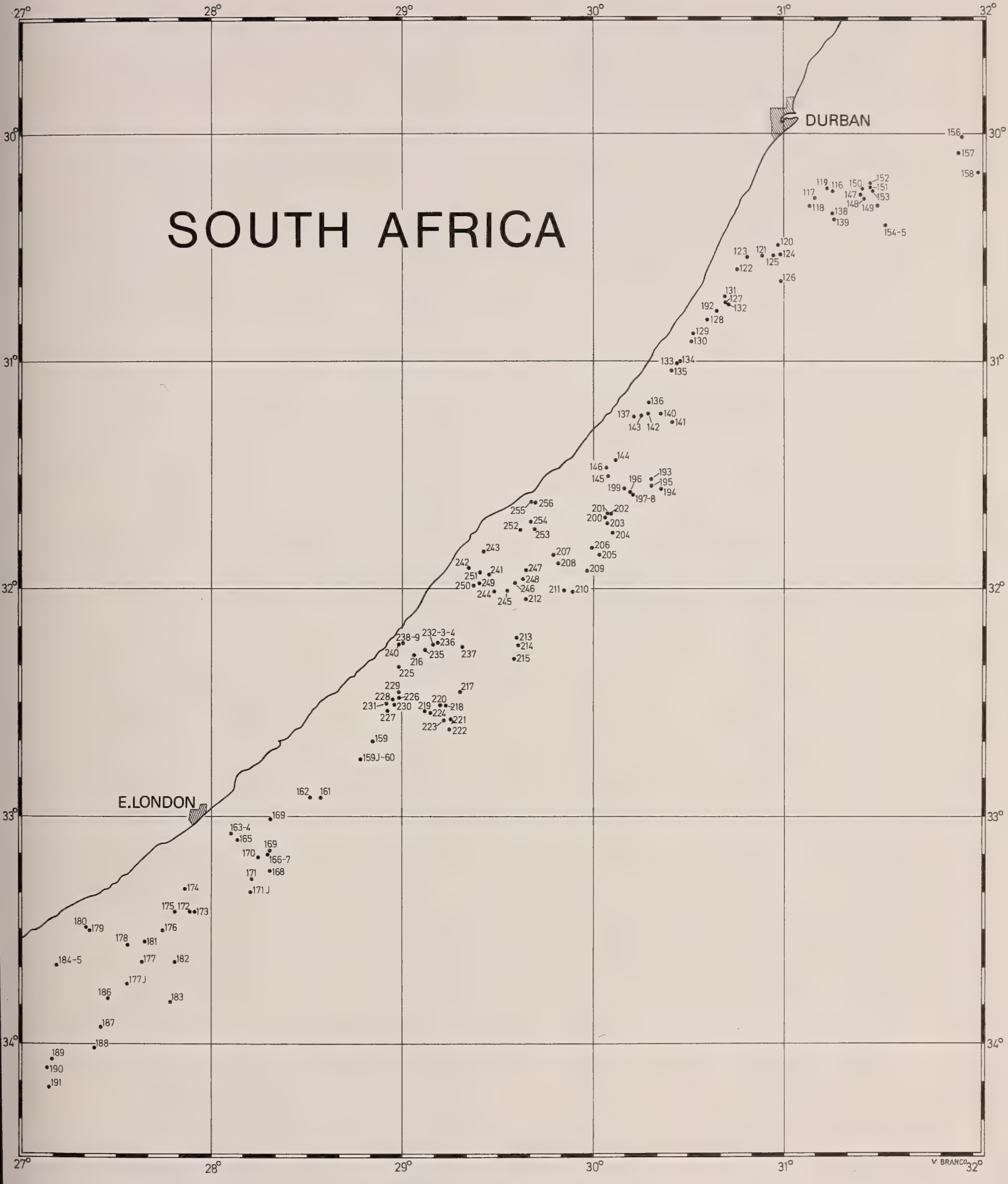

Fig. 2. Stations occupied off the east coast of South Africa, south of Durban, during the cruises of the South African Museum on the R.V. *Meiring Naude*.

Methods for taking measurements and counts follow Nafpaktitis (1973) and their abbreviations follow Hulley (1981). Additional abbreviations include:

SAM	South African Museum catalogue number
SM	*Meiring Naude* station number
A	*Africana II* station number (Hulley 1972; illustration only)
IK	IKMT survey station number (Grindley & Penrith 1965; illustration only)

Ranges in standard length (SL) for each species at each station are given in the *Species list*; maximum lengths are given in the species descriptions and are taken from the literature. Photophore groupings and nomenclature are in accordance with Paxton (1972). The state of sexual maturity in the case of females is given as follows:

Stage I	Ovaries immature, eggs minute and transparent
Stage II	Ovaries immature, eggs small and granular
Stage III	Ovaries developing, both large and small eggs present (no oil droplets)
Stage IV	Ovaries developed, eggs large (no oil droplets)
Stage V	Ovaries mature, eggs large with oil droplets
Stage VI	Ovaries spent

All specimens are housed in the collection of the Department of Marine Biology, South African Museum.

SPECIES LIST

	SAM No.	No.	SL (mm)	SM station	Depth (m)
Benthosema fibulatum	29041	1	15,0	87S	45–0
	29060	1	13,8	62D	209–0
	29085	1	13,0	79D	200–0
	29145	1	15,3	70D	200–0
Benthosema suborbitale	27543	2	20,9–28,8	97	467–0
	27663	1	26,1	96	465–0
	27982	2	25,5 + head	119	750–0
	27983	2	25,5–28,4	125	415–0
	27984	1	22,0	126	464–0
	27985	2	26,1–26,5	132	830–0
	27986	1	23,2	139	250–0
	27987	1	19,6	153	664–0
	28316	1	24,7	190	658–0
	28365	12	16,2–28,4	191	542–0
	28701	1	21,0	199	250–0
	29032	1	11,3	110S	45–0
	29036	1	13,8	12	200–0
	29039	1	23,3	11	150–0
	29049	3	13,1–18,3	124D	212–0
	29054	1	25,0	54D	200–0
	29055	2	11,1–11,8	13	274–0
	29091	2	12,7–26,7	34	212–0
	29124	1	10,5	188D	212–0
	29152	1	22,9	80	359–0
	29161	1	10,3	54S	45–0

	SAM No.	No.	SL (mm)	SM station	Depth (m)
Bolinichthys indicus	27665	1	16,2	112	488–0
	27990	1	23,2	126	464–0
	27991	1	38,0	140	1120–0
	27992	1	24,0	145	1129–0
	28369	1	17,2	191	542–0
	29029	1	12,2	118D	212–0
	29042	1	12,0	80	359–0
	29078	1	19,7	20	580–0
	29208	1	12,8	168	816–0
	29609	1	12,4	79D	200–0
Bolinichthys supralateralis	26614	1	45,0	52	720–0
	27102	1	29,7	25	600–0
	27110	1	23,0	25	600–0
	27529	1	23,1	105	775–0
	27988	1	26,4	119	750–0
	27989	2	15,8–20,9	132	830–0
	28284	1	26,7	168	816–0
	28309	1	18,9	160	583–0
	29028	1	12,4	80	359–0
	29143	1	14,9	45	212–0
Ceratoscopelus warmingii	27517	1	22,8	112	488–0
	27538	1	28,2	88	297–0
	27662	1	16,4	97	467–0
	27993	1	17,7	126	464–0
	27994	2	21,0–51,5	132	830–0
	27795	2	17,6–31,2	139	250–0
	27996	2	36,9–43,3	140	1120–0
	27997	4	18,2–43,4	153	664–0
	27998	1	18,6	154	500–0
	27999	6	29,1–42,7	148	750–0
	28283	5	17,6–36,1	190	658–0
	28285	1	23,1	160	583–0
	28286	1	15,9	168	816–0
	28287	3	17,4–24,7	167	1091–0
	28288	1	39,3	173	683–0
	28289	1	18,1	186	583–0
	28655	1	16,3	220	1416–0
	28678	1	27,0	218	916–0
	28702	1	36,0	214	1390–0
	29037	1	16,9	104D	200–0
	29052	1	16,7	87D	200–0
	29098	1	16,3	79D	200–0
	29093	1	16,4	143D	212–0
	29113	1	18,9	200D	212–0
	29131	1	18,3	188D	212–0
	29150	1	26,8	12	200–0
Diaphus aliciae	28332	1	16,8	174	760–0
	29142	1	12,9	152D	212–0
Diaphus brachycephalus	27113	1	26,3	33	400–0
	28361	2	29,0–30,3	160	583–0
Diaphus diadematus	27105	4	28,4–34,6	18	600–0
	27125	1	21,2	49	400–0
	27498	1	34,7	111	514–0
	27504	5	31,0–32,6	63	140–0

	SAM No.	No.	SL (mm)	SM station	Depth (m)
Diaphus diadematus (contd.)	27514	3	28,8–36,8	112	488–0
	27524	2	24,8–29,6	105	775–0
	27536	2	24,5–31,9	88	297–0
	27542	1	21,7	55	400–0
	27544	1	34,5	97	467–0
	28000	1	29,7	132	830–0
	28001	1	32,5	148	750–0
	28002	3	25,4–29,5	153	664–0
	28003	1	31,7	154	500–0
	28342	1	25,6	168	816–0
	28672	2	28,0–30,3	221	1170–0
	28673	1	24,6	211	415–0
	29127	1	12,7	222D	193–0
	29134	1	10,8	80	359–0
	29135	2	9,7–14,3	124D	212–0
	29151	1	10,7	143D	212–0
	29157	1	15,3	62D	209–0
	29172	1	19,3	104D	200–0
	29177	2	13,8–15,2	95D	200–0
	29185	1	14,9	20	528–0
Diaphus effulgens	27500	1	33,1	111	514–0
	27522	2	25,0–31,0	112	488–0
	28004	2	31,8–37,4	132	830–0
	28248	1	31,8	132	830–0
	28290	1	35,6	191	542–0
	28291	1	31,7	160	583–0
	29178	2	20,3–29,0	118D	212–0
Diaphus garmani	27511	1	26,4	56	397–0
	29180	1	30,1	80	359–0
	29184	2	12,4–14,3	143D	212–0
	29188	1	13,1	136D	212–0
Diaphus hudsoni	28006	1	78,6	128	930–0
	28292	1	90,0	190	658–0
Diaphus jenseni	28293	1	26,6	183	474–0
Diaphus lucidus	27523	1	34,9	112	488–0
	27530	1	42,7	105	775–0
	28007	1	32,9	126	464–0
	28008	3	15,0–28,8	132	830–0
	28009	2	30,8–57,3	139	250–0
	28010	1	29,6	140	1120–0
	28011	2	39,9–46,9	153	664–0
	28294	1	33,4	160	583–0
	28295	6	17,7–39,5	168	816–0
	28296	2	12,5–38,3	170	708–0
	28302	4	16,4–41,7	191	542–0
	28674	1	46,7	204D	212–0
	28675	1	26,0	208	1320–0
	28676	1	36,3	216	0
	29133	1	16,5	12	200–0
	29149	3	37,9–40,5	143D	212–0
	29176	1	17,2	80	350–0
Diaphus luetkeni	27497	1	24,6	111	514–0
	27545	1	19,7	55	400–0
	28012	2	29,0–39,9	153	664–0

	SAM No.	No.	SL (mm)	SM station	Depth (m)
Diaphus luetkeni (contd.)	28013	1	19,8	119	750–0
	28014	1	37,5	148	750–0
	28015	2	20,2–28,0	132	830–0
	28016	1	40,6	139	250–0
	28017	1	36,8	138	830–0
	29174	1	16,3	143D	212–0
Diaphus metopoclampus	27503	1	33,0	63	140–0
	27525	1	49,7	105	775–0
	27664	1	18,8	112	488–0
	28018	1	25,3	132	830–0
	28297	1	12,0	187	982–0
Diaphus mollis	27104	1	56,1	25	600–0
	27499	1	42,0	111	514–0
	27515	1	31,7	112	488–0
	27526	2	29,4–31,9	105	775–0
	27537	1	45,0	88	297–0
	28019	1	35,7	119	750–0
	28020	1	15,0	125	415–0
	28021	1	29,9	126	464–0
	28022	2	28,6–31,7	132	830–0
	28023	1	49,5	145	1129–0
	28318	1	19,4	190	658–0
	28341	1	15,6	168	816–0
	28351	2	23,4–25,5	183	474–0
	28352	1	19,3	186	583–0
	28360	1	27,5	160	583–0
	28363	1	13,4	159	690–0
	28685	1	57,3	223	670–0
	29125	1	15,5	188D	212–0
	29136	1	14,2	95S	45–0
	29137	1	13,3	12	200–0
	29148	2	14,7–35,4	152D	212–0
	29155	2	23,5–33,5	20	528–0
	29173	1	14,8	104D	200–0
	29187	1	11,3	95D	200–0
Diaphus nielseni	28029	2	27,7–35,0	148	750–0
Diaphus parri	28684	1	25,0	221	1170–0
	29138	2	14,0–15,6	80	359–0
	29139	1	11,5	110D	200–0
	29141	1	12,5	11	150–0
	29156	1	11,5	70D	200–0
	29175	1	23,3	143D	212–0
	29183	1	12,9	87S	45–0
Diaphus perspicillatus	28005	1	32,0	145	1129–0
	28028	2	19,6–29,9	153	664–0
	28298	1	21,9	173	683–0
	28299	1	21,6	183	474–0
	28300	1	24,6	171	792–0
	29190	3	14,0–17,3	169D	212–0
	29197	3	11,3–16,3	143S	50–0
Diaphus problematicus	28024	1	55,8	126	464–0
Diaphus richardsoni	28025	1	44,8	132	830–0
	28319	1	11,3	190	658–0

	SAM No.	No.	SL (mm)	SM station	Depth (m)
Diaphus richardsoni (contd.)	28376	1	20,4	187	982–0
	29140	1	9,7	146D	212–0
Diaphus splendidus	27512	1	29,9	56	397–0
	28026	1	59,5	132	830–0
	29179	2	20,6–21,3	118D	212—0
	29181	1	19,3	110D	200–0
	29186	1	23,0	13	274–0
Diaphus sp.	28027	1	19,6	139	250–0
	28301	3	12,6–16,4	168	816–0
	29189	1	11,2	54S	45–0
	29191	3	8,3–10,3	118D	212–0
	29192	1	11,6	143D	212–0
	29193	1	8,4	87D	200–0
	29194	1	9,8	54D	200–0
	29195	1	8,9	95D	200—0
	29196	3	10,2–12,0	188D	212–0
	29198	4	8,2–10,4	124D	212–0
Diogenichthys atlanticus	28336	1	19,7	171	792–0
	28337	2	13,8–17,7	168	816–0
	28699	1	14,2	218	916–0
	29117	1	13,8	222D	193–0
Diogenichthys panurgus	28030	1	14,3	125	415–0
	28031	1	18,7	139	250–0
	28032	1	19,4	148	750–0
	28033	1	12,4	157	750–0
	28336	1	18,8	191	542–0
	29043	1	12,1	143S	50–0
	29056	1	10,8	152D	212–0
	29065	2	17,4–17,7	136D	212–0
	29066	1	17,0	20	528–0
	29079	1	10,4	104D	200–0
	29082	1	18,7	143D	212—0
	29103	1	10,3	249S	53–0
	29120	1	10,6	196D	212–0
	29129	2	10,6–11,5	188D	212–0
Gonichthys barnesi	28314	1	39,7	188N	0
	28671	1	41,7	196N	0
Hygophum hanseni	28331	1	37,1	173	683–0
	28334	1	28,0	174	760–0
	28338	2	27,6–34,3	168	816–0
	28355	1	28,4	160	583–0
	28683	1	28,9	221	1170–0
Hygophum hygomii	27108	2	50,4–52,1	18	600–0
	28034	2	47,2–49,8	153	664–0
	28315	1	51,3	188N	0
	28339	1	12,3	168	816–0
	28340	1	13,3	168	816–0
	28374	1	12,9	170	708–0
	28646	2	55,0–56,0	204N	0
	28681	1	52,4	222N	0
	28694	1	47,0	198	0
	29063	2	50,3–52,4	155N	0
	29075	1	19,2	118D	212–0
	29106	3	13,3–14,1	249S	53–0

	SAM No.	No.	SL (mm)	SM station	Depth (m)
Hygophum hygomii (contd.)	29108	1	13,1	222S	43–0
	29126	4	14,3–19,7	118N	0
	29153	1	15,0	13	274–0
	29159	1	12,3	19	226–0
Hygophum proximum	29095	1	11,0	143D	212–0
	29098	1	22,3	19	226–0
Lampadena luminosa	27518	1	24,8	112	488–0
	27527	1	23,0	105	775–0
Lampadena notialis	28035	1	24,7	148	750–0
	28368	1	25,1	191	542–0
	29160	1	17,0	45	500–0
Lampadena speculigera	28643	1	126,6	195	1050–0
Lampanyctus achirus	28375	1	71,2	187	982–0
	28647	1	124,4	221	1170–0
	28666	1	136,8	195	1050–0
	28699	1	91,0	195	1050–0
Lampanyctus alatus	27103	2	43,7–44,7	25	600–0
	27106	1	42,1	18	600–0
	27507	2	41,9–48,2	63	140–0
	27508	1	30,2	56	397–0
	27520	4	37,3–41,4	112	488–0
	27535	2	25,0–30,0	88	297–0
	27660	1	22,4	105	775–0
	27661	1	18,6	96	465–0
	28036	1	31,7	119	750–0
	28037	2	36,8–42,7	132	830–0
	28038	1	45,0	140	1120–0
	28039	1	35,6	145	1129–0
	28040	1	24,7	153	664–0
	28041	2	36,9–38,1	154	500–0
	28042	1	38,3	157	750–0
	28058	1	20,2	148	750–0
	28303	1	20,8	191	542–0
	28317	1	25,5	190	658–0
	28329	3	35,8–42,0	173	683–0
	28343	1	21,9	168	816–0
	28347	2	27,8–33,3	167	1091–0
	28364	1	22,0	159	690–0
	28377	1	36,4	187	982–0
	28656	3	38,8–50,1	220	1416–0
	28679	3	45,3–49,3	218	916–0
	28689	1	46,7	214	1390–0
	28690	1	50,0	221	1170–0
	29034	1	22,4	62D	209–0
	29045	1	21,1	124D	212–0
	29048	2	14,0–15,6	62D	209–0
	29058	1	20,5	152D	212–0
	29068	1	14,4	79D	200–0
	29077	1	19,5	80	350–0
	29084	1	22,8	95D	200–0
	29092	1	13,5	95D	200–0
	29096	1	16,6	87D	200–0
	29101	1	29,9	143D	212–0
	29107	1	13,4	222S	43–0
	29116	1	17,4	196D	212–0

	SAM No.	No.	SL (mm)	SM station	Depth (m)
Lampanyctus alatus (contd.)	29158	2	36,5–37,0	34	212–0
	29166	1	18,0	143D	212–0
	29366	1	15,9	168	816–0
Lampanyctus ater	28044	1	105,4	148	750–0
Lampanyctus ?ater	27507	1	93,0	99	920–0
	28403	1	78,0	153	664–0
Lampanyctus australis	27112	1	101,0	7	840–0
	27539	1	101,8	83	810–0
	28045	2	88,9–90,3	132	830–0
	28046	1	101,8	138	830–0
	28047	3	42,0–98,0	148	750–0
	28048	1	97,5	153	664–0
	28061	1	63,5	148	750–0
	28325	1	38,2	173	683–0
	28326	5	52,3–101,4	173	683–0
	28348	3	41,9–48,9	167	1091–0
	28645	3	85,1–98,6	224	663–0
	28649	1	93,4	223	670–0
	28650	1	94,3	209	1260–0
	28651	1	83,7	220	1416–0
	28652	2	88,5–91,3	218	916–0
	28680	1	35,4	218	916–0
	28691	1	49,4	221	1170–0
	29371	1	34,0	154	500–0
Lampanyctus festivus	27534	2	59,4–72,6	56	397–0
	28686	1	31,6	218	916–0
Lampanyctus lepidolychnus	27095	2	89,8–92,1	18	600–0
	27096	1	73,6	5	450–0
	27111	2	101,8–104,6	33	400–0
	27519	1	35,6	112	488–0
	27521	3	73,8–97,2	63	140–0
	27532	1	104,1	111	514–0
	27533	2	93,4–97,5	56	397–0
	28049	1	97,7	126	464–0
	28050	1	95,0	132	830–0
	28051	2	81,4–105,5	138	830–0
	28052	6	34,4–95,0	148	750–0
	28053	9	33,7–90,1	153	664–0
	28054	10	30,3–101,6	154	500–0
	28055	2	36,2–42,8	157	750–0
	28107	2	76,4–89,6	140	1120–0
	28327	1	62,9	173	683–0
	28328	4	36,6–45,8	173	683–0
	28333	1	43,1	174	760–0
	28349	2	35,0–39,0	167	1091–0
	28353	2	36,7–79,4	186	583–0
	28354	1	36,3	182	1517–0
	28359	2	46,1–53,8	160	583–0
	28375	1	96,8	187	982–0
	28642	4	89,5–109,4	194	2166–0
	28653	2	97,2–101,5	218	916–0
	28654	3	84,7–101,6	209	1260–0
	28665	1	103,7	195	1050–0
	28667	1	92,1	209	1260–0

	SAM No.	No.	SL (mm)	SM station	Depth (m)
Lampanyctus nobilis	28056	1	54,6	157	750–0
	28358	1	45,0	160	583–0
Lampanyctus pusillus	28057	1	24,9	119	750–0
	28059	1	29,5	132	830–0
	29046	1	29,7	124D	212–0
	29128	1	14,6	188D	212–0
Lampanyctus turneri	27510	1	20,1	56	397–0
	28062	3	42,4–54,5	148	750–0
	28063	1	39,8	119	750–0
	28064	1	57,3	125	415–0
	28065	1	60,5	140	1120–0
	28066	1	51,8	153	664–0
	28067	1	24,0	154	500–0
	28322	1	31,3	173	683–0
	28323	2	24,0–28,0	173	683–0
	28371	1	33,0	170	708–0
	29169	1	20,0	143D	212–0
Lampanyctus sp. A	28060	1	66,6	125	415–0
	28330	1	76,5	173	683–0
Lobianchia dofleini	27501	1	29,6	111	514–0
	27506	2	31,4–32,0	63	140–0
	28068	1	26,2	154	500–0
	28069	1	29,7	148	750–0
	28070	1	28,2	157	750–0
	28071	1	29,5	153	664–0
	28072	1	27,6	138	830–0
	28073	3	28,1–33,7	139	250–0
	28074	1	29,1	140	1120–0
	28350	3	22,0–31,3	183	474–0
	28357	1	30,0	160	583–0
	28372	1	26,8	170	708–0
	28700	1	35,5	199	250–0
	28750	1	34,1	197	150–0
	29097	1	28,2	45	212–0
Lobianchia gemellarii	28698	1	41,1	218	916–0
	29182	1	19,0	104D	200–0
Myctophum asperum	28075	1	26,0	154	500–0
	29072	1	20,6	95D	200–0
	29121	1	14,4	170N	0
	29130	2	14,3–14,6	188N	0
	29165	2	26,4–27,0	155N	0
	29167	1	19,9	95S	45–0
	29168	1	28,3	152N	0
Myctophum aurolaternatum	29030	1	59,3	155N	0
	29035	1	37,4	95N	0
	29038	1	40,2	124D	212–0
Myctophum nitidulum	27107	3	20,9–24,4	45	212–0
	28076	1	57,0	148	750–0
	28304	1	22,6	191	542–0
	28307	1	24,8	190	658–0
	28692	1	16,1	205	585–0
	28695	1	40,1	198N	0

	SAM No.	No.	SL (mm)	SM station	Depth (m)
Myctophum nitidulum (contd.)	28696	1	52,7	199N	0
	29044	3	14,7–25,9	95N	0
	29059	3	15,4–23,8	124N	0
	29061	1	17,1	62N	0
	29076	4	16,4–32,3	155N	0
	29083	1	16,1	198	0
	29090	1	21,8	110N	0
	29102	2	28,6–29,9	152N	0
	29112	1	26,5	160N	0
Myctophum obtusirostre	28310	1	35,8	170N	0
	29099	1	67,9	152N	0
	29170	3	14,4–15,4	152N	0
	29215	1	14,6	188N	0
Myctophum phengodes	27516	1	28,7	112	488–0
	28305	2	26,5–36,9	191	542–0
	28313	1	51,0	188N	0
	28682	1	44,6	222N	0
	28697	1	45,7	223	670–0
	29801	1	39,0	110N	0
Myctophum spinosum	28077	1	58,6	153	664–0
	28311	1	32,8	170N	0
	28670	1	54,9	196N	0
	28688	1	53,4	222N	0
	29053	1	22,1	62N	0
	29071	1	14,4	104D	200–0
	29105	1	16,2	170N$_2$	0
	29118	1	24,7	170N$_1$	0
	29132	3	15,5–23,8	188N	0
	29147	1	30,2	124N	0
	29164	4	20,0–48,1	155N	0
Notolychnus valdiviae	28078	3	11,6–17,8	125	415–0
	28079	4	18,4–19,6	119	750–0
	28080	1	19,6	139	250–0
	28320	1	17,0	190	658–0
	28335	1	20,6	171	792–0
	28344	2	20,7–20,8	168	816–0
	28345	1	18,6	107	1200–0
	28356	1	19,1	160	583–0
	28367	1	20,6	191	542–0
	28373	1	18,1	170	708–0
	29031	3	11,9–17,4	124D	212–0
	29033	3	11,4–18,5	110D	200–0
	29050	3	10,3–18,0	152D	212–0
	29051	2	12,6–17,4	62D	209–0
	29057	1	17,8	118D	212–0
	29067	1	9,6	95D	200–0
	29074	1	18,6	11	150–0
	29080	1	9,9	45	212–0
	29086	3	12,1–16,0	104D	200–0
	29088	3	15,2–15,9	45	212–0
	29094	1	11,2	70D	200–0
	29100	1	19,6	143D	212–0
	29122	1	11,6	169D	212–0
	29144	1	13,0	95S	45–0
	29162	1	16,4	54D	200–0

	SAM No.	No.	SL (mm)	SM station	Depth (m)
Notoscopelus caudispinosus	28362	3	17,8–19,6	159	690–0
	29110	1	20,4	189D	212–0
Notoscopelus resplendens	27528	1	61,7	105	775–0
	28081	2	56,2–60,1	148	750–0
	28082	1	48,6	154	500–0
Scopelopsis multipunctatus	27097	3	48,6–60,9	18	600–0
	27098	11	49,1–65,8	47	400–0
	27099	5	47,9–61,0	5	450–0
	27100	3	50,1–54,6	25	600–0
	27114	1	49,1	33	400–0
	27124	1	65,1	49	400–0
	27513	2	52,8–55,0	112	488–0
	28083	1	54,6	145	1129–0
	28084	4	49,8–51,6	139	250–0
	28085	2	50,1–51,1	148	750–0
	28086	1	50,2	153	664–0
	28321	1	46,1	190	658–0
	28657	1	61,0	224	663–0
	28658	1	51,5	253	1010–0
	28659	1	54,0	197	150–0
	28660	1	51,6	209	1260–0
	28661	1	55,1	194	2166–0
	28662	1	58,0	220	1416–0
	28663	1	61,4	218	916–0
	28664	4	51,0–62,6	199	250–0
	28668	4	47,9–58,4	208	1320–0
	29114	2	51,9–52,8	244D	172–0
	29123	1	15,5	222D	193–0
Symbolophorus barnardi	27126	1	53,7	49	400–0
	27531	1	92,7	105	775–0
	27540	1	97,3	63N	0
	28370	1	49,3	170N	0
	28644	1	88,5	192	0
	28648	1	84,8	209	1260–0
Symbolophorus evermanni	27541	1	59,1	63	140–0
	28087	2	35,3–56,6	148	750–0
	28088	1	34,5	153	664–0
	28687	1	29,6	210N	0
	29047	1	18,4	62D	209–0
	29073	1	20,2	110N	0
	29087	2	19,8–20,3	198	0
	29104	3	18,3–19,3	170N$_2$	0
	29109	1	19,2	196N	0
	29111	1	18,9	210N	0
	29115	1	20,3	222N	0
	29119	2	17,7–18,4	170N$_1$	0
	29154	4	18,6–22,3	155N	0
	29163	1	25,5	54S	45–0
	29171	1	18,2	26	212–0
Taaningichthys bathyphilus	28089	1	51,3	138	830–0
	28090	1	55,0	157	750–0
	28677	1	51,0	218	916–0
Triphoturus nigrescens	28038	3	23,0–27,8	190	658–0
	28091	1	27,6	125	415–0

SAM No.	No.	SL (mm)	SM station	Depth (m)
28092	1	32,0	153	664–0
28093	3	28,3–30,1	148	750–0
28094	1	33,6	157	750–0
28324	1	30,9	173	683–0
28346	1	25,7	167	1091–0
29040	1	17,1	104D	200–0
29062	1	16,6	70D	200–0
29070	2	18,3–29,7	143D	212–0
29146	1	13,5	80	359–0
29365	1	27,0	62S	45–0

SYSTEMATIC ACCOUNT

Benthosema fibulatum (Gilbert & Cramer, 1897)

Fig. 3

Remarks

A single specimen (SAM–27462), taken at 42°11′S 19°26′E, was previously recorded from the southern African region (Wisner 1976). The *Meiring Naude* specimens, all immature (female stage I) and taken in Bongo nets between 200 m and the surface at sundown from the region of 27°S, were caught during the 1976 cruise only. Surface temperatures ranged above 25 °C at these stations, and water of an equivalent temperature was found at least to a depth of 75 m, with a minimum temperature of 14,18 °C at maximum trawling depth. This would suggest that the species probably penetrates the region with the Agulhas Current and does not breed in southern African waters.

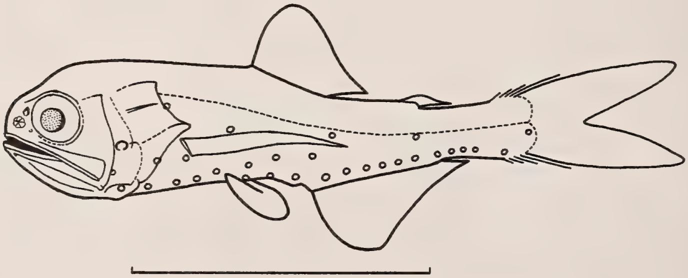

Fig. 3. *Benthosema fibulatum* (A 2957). Scale 10 mm.

Benthosema suborbitale (Gilbert, 1913)

Remarks

Hulley (1981) reports that the distribution of the species in the Atlantic is related to the 15 °C isotherm at 200 m. During the *Meiring Naude* cruises, specimens were taken at seven stations at which the temperature at 200 m was below this value (minimum value 12,84 °C) but, in all cases, warm water with a minimum value of 15,5 °C occurred in the upper 100 m. The species was taken in the upper 50 m on two occasions and juvenile specimens (less than 12 mm) in the upper 45 m. Sexually mature specimens (female stage V) were present in the material.

Bolinichthys indicus (Nafpaktitis & Nafpaktitis, 1969)

Fig. 4

Remarks

The specimens have been tentatively referred to *B. indicus* solely on the basis of their geographic distribution. Although Nafpaktitis & Nafpaktitis (1969) have given characteristics for the separation of *B. indicus* and *B. longipes*, these are not satisfactory diagnostics in the case of the *Meiring Naude* material. All specimens, except for two females (Fig. 4) from each of stations SM 140 and SM 145, are characterized by a low GR count (less than 17) typical of *B. indicus*. However, a luminous patch above the pectoral fin may be present or absent; luminous scales at the dorsal base vary between 0 and 2, and at the anal base between 1 and 2; the length of the infracaudal gland as a percentage of CPD varies between 50,0 and 88,5 % (mean 65,4 %), and the supracaudal gland as a percentage of the infracaudal gland between 43,5 and 87,5 % (mean 70,0 %); and the infracaudal gland reaches the last AOp in only 50 % of the specimens. The two female specimens (GR 17) fall within the range of overlap of the two species in this diagnostic. In these specimens, the luminous patch above the pectoral fin is absent, there are 2–3 scales at the dorsal base and a single scale at the anal base; the infracaudal length varies between 50,7 and 52,4 % CPD and the supracaudal between 72,7 and 77,3 % of infracaudal length; and the infracaudal gland does not reach the last AOp. This, together with the fact

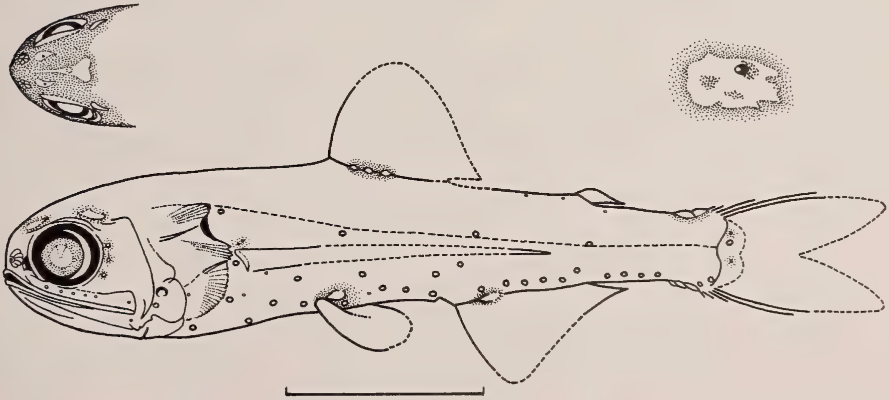

Fig. 4. *Bolinichthys indicus* (SM 140), with dorsal view of head and right supraorbital luminous patch. Scale 10 mm.

that *B. indicus* and *B. longipes* were never taken at the same station during the R.V. *Anton Bruun* cruises, particularly between 10°N and 20°S (Nafpaktitis & Nafpaktitis 1969), suggests that the taxonomic status of the two species should be more fully investigated.

Bolinichthys supralateralis (Parr, 1928)

Remarks

No sexually mature specimens were taken during the *Meiring Naude* cruises.

Ceratoscopelus warmingii (Lütken, 1892)

Remarks

Immature specimens only occur in the *Meiring Naude* material (stages I–III), but there are females with well-developed ovaries (stage IV) from west of Slangkop Lighthouse and from 36°47′S 34°40′E in the SAM collection.

Diaphus aliciae Fowler, 1934

Fig. 5

Diaphus aliciae Fowler, 1934: 295, fig. 53 (between Bohol and Leyte, Philippines). Nafpaktitis, 1978: 73, figs 72–74.

Description

D 14; A 13; P 10; AO 5 + 4, total 9; GR 5 + 1 + 11, total 17.

Measurements (% SL): BD 24,8–25,6; HD 23,3–23,6; UJ 18,5–20,2; ED 10,2–10,9; CPD 9,9–10,5; CPL 20,9–21,3.

Posterodorsal margin of operculum more or less angulate. Origin of dorsal fin about above ventral base. Pectoral fins damaged, ventral fins reaching to origin of anal fin or slightly beyond. Origin of anal fin posterior to vertical through base of last dorsal ray. Origin of adipose fin slightly anterior to vertical through base of last anal ray. Gill rakers lath-like. Dorsal base shorter than length of upper jaw and longer than anal base.

Dn about size of nasal rosette, in deep recess and directed anteriorly. Vn short, less than distance between it and So. So small, slightly posterior to vertical through centre of pupil. Op_1 opposite posterior end of upper jaw; Op_2 about size of general body photophore, situated below level of ventral margin of orbit. PLO 1,5 times nearer to upper pectoral base than to lateral line and associated with a small, luminous scale. PO_1, PVO_1, PVO_2 in same straight, oblique line, with PVO_2 at lower end of base of pectoral fin. PO_1–PO_2 interspace greater than PO_2–PO_3 and PO_3–PO_5 interspaces, with PO_4 slightly posterior to vertical through PO_3, and PO_5 elevated and anterior to outermost ray of ventral fin. VLO about midway between base of ventral fin and lateral line. VO_1–VO_3 on same straight, oblique line. SAO slightly angulate; with SAO_1 above anus and at about level of VO_3, with SAO_2 immediately behind SAO_1 and above level of VO_3, and with SAO_3 about above anal origin and about 1,5–2,0 times its diameter below lateral line. AO series about one photopore diameter apart, with AOa^1 elevated, and with all AOp behind anal base. Pol under base of adipose fin, about 1,5 times its diameter below lateral line. Prc curved; Prc_4 about 1,5 times its diameter below level of lateral line.

Maximum length 60 mm; sexually mature from about 45 mm. Indian Ocean specimens smaller—maximum length 39 mm and sexually mature from about 35 mm.

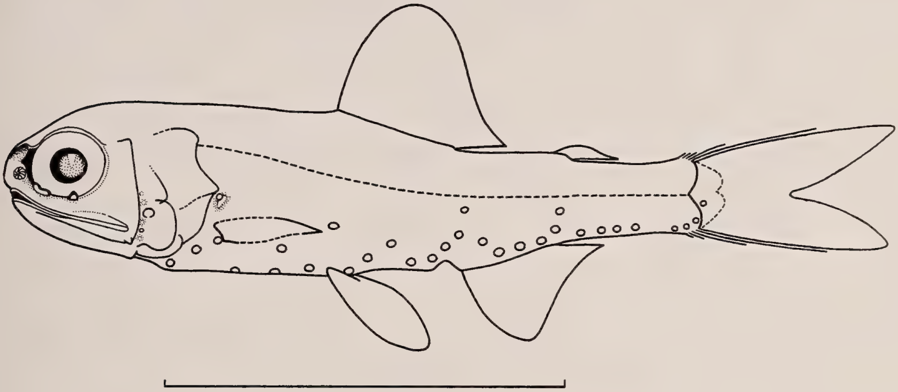

Fig. 5. *Diaphus aliciae* (SM 174). Scale 10 mm.

Distribution

Indian Ocean and south-eastern Asian seas: west of 70°E between 10°N and 12°S, east of 85°E between 05°N and 09°S. Pacific Ocean: off northern Kyushu.

Remarks

The *Meiring Naude* specimens, both of which are immature, represent the first record of the species in the southern African region.

Diaphus brachycephalus Tåning, 1928

Remarks

No sexually mature adults were present in the *Meiring Naude* material, but stage IV females are known to at least 37°S in the region.

Diaphus diadematus Tåning, 1932

Remarks

This is one of the most common species of *Diaphus* off the east coast of South Africa. A single, sexually mature female (stage V, 28,8 mm) was taken by the *Meiring Naude* (SM 112), but stage IV females were taken as far south as 31°S. This, coupled with the fact that sexually mature adults are found in the eastern South Atlantic and the fact that there are no statistically valid differences in meristics between these specimens and those from the western South Indian Ocean (D: t −0,40; df 52; A: t 1,84; df 54; P: t −1,18; df 26; AOa: t −0,15; df 98; AOp: t 3,16; df 97; AO$_T$: t 2,99; df 97; GR$_u$: t 2,87; df 67; GR$_l$: t 1,27; df 67; GR$_T$: t 2,50; df 67), confirms that a single population is involved. The Vn in males is horizontally striated in the *Meiring Naude* specimens, as pointed out by Nafpaktitis (1978) for the western Indian Ocean population.

Diaphus effulgens (Goode & Bean, 1896)

Remarks

Analysis of GR counts between specimens of this species from the South Atlantic and those taken by the *Meiring Naude* in the western South Indian Ocean reveals significant differences only in GR$_u$ count (t 4,23; df 59), with higher values for the South Atlantic specimens.

Diaphus garmani Gilbert, 1906

Remarks

All specimens taken by the *Meiring Naude* are immature.

Diaphus hudsoni Zubrigg & Scott, 1976

Remarks

Nafpaktitis (1978) has suggested that the apparent absence of the species in the Indian Ocean may be due to inadequate sampling. Grindley & Penrith (1965) reported specimens of this species from off Cape Agulhas as *D. theta* (IK 38, IK 39, IK 40). The two *Meiring Naude* specimens were taken at 30°49′S 30°35′E and 34°06′S 27°08′E, where the temperature at 200 m was 14,18 °C, and 14,60 °C respectively. The species may extend northwards in this region to 26°40′S since two specimens (45–47 mm), identified as *Diaphus richardsoni* by Grindley & Penrith (1965), proved on re-examination to be specimens of *D. hudsoni*. This northern limit in the western South Indian Ocean is farther to the north of that for the species in the eastern South Atlantic, outside the Benguela Upwelling Region (Hulley 1981), and would support both Heydorn's (1976) and Carter's (1977) findings on the northern transport of the biota in association with the northward advection of pockets of cooler water. Carter (1977, figs 40–43) demonstrates that in the region north of 28°S, the 15°C isotherm varies between 60 m and 140 m, inshore of the Agulhas Current core.

Diaphus jenseni Tåning, 1928

Fig. 6

Diaphus jenseni Tåning, 1928: 141, fig. 14 (03°18′N 129°02′E). Nafpaktitis, 1973: 24, fig. 22; 1978: 21, figs 18–19. Wisner, 1976: 112, fig. 101. Parin *et al.*, 1977: 117, fig. 18. Kawaguchi & Shimizu, 1978: 110, figs 42–43. Kotthaus, 1979: 51, figs 509, 514.

Diaphus kylei Tåning, 1932: 133, fig. 5 (07°22′N 121°16′E). Nafpaktitis, 1973: 20, fig. 17.

Diaphus gudgeri Fowler, 1934: 302, fig. 59 (northern Mindanao, Philippines).

Diaphus carlsoni Fowler, 1934: 312, fig. 67 (12°38′30″N 121°37′30″E).

Description

D 15; A 14; P 11; AO 6+5, total 11; GR 6+1+12, total 19.

Origin of dorsal fin slightly in advance of base of ventral fin. Origin of anal fin behind vertical through base of last dorsal ray. Origin of adipose fin slightly behind vertical through base of last anal ray. Pectoral fin not reaching base of ventral fin; ventral fin not reaching anal origin.

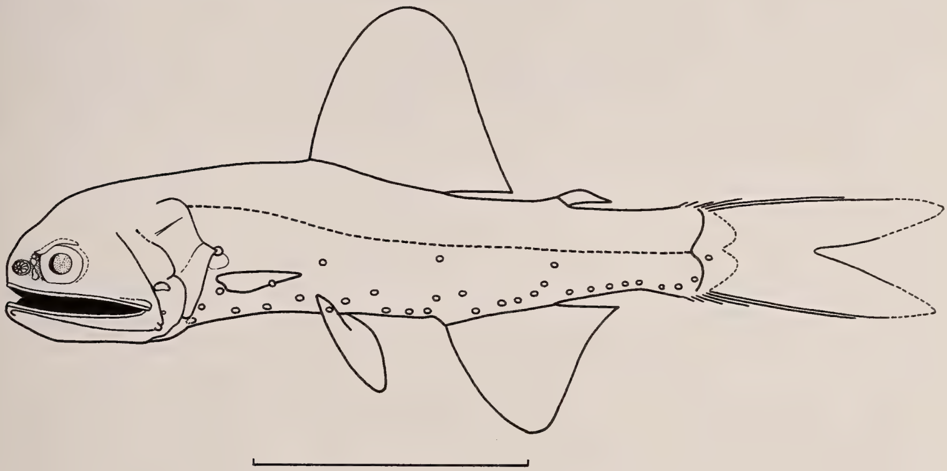

Fig. 6. *Diaphus jenseni* (SM 183). Scale 10 mm.

Dn small, heart-shaped and directed anterolaterally; Vn about same size as Dn, situated at anteroventral margin of orbit. Ant present, dorsad to Dn. Op_1 small and about opposite posterior end of maxilla; Op_2 larger than general body photophore, situated above Op_1 and at about level of ventral margin of orbit. PLO much nearer to upper base of pectoral fin than to lateral line. VLO about equidistant between outer base of ventral fin and lateral line. SAO series slightly angulate, with SAO_1 in line with VO_4 and VO_5, but well behind VO_5, with SAO_2 above anus at about level of VO_2, and with SAO_3 slightly behind vertical through SAO_2 and about 1,5 times its diameter below lateral line. AOa^1 abruptly elevated, above level of SAO_2; AOa^2–AOa^3 interspace enlarged; no AOp photophores above base of anal. Pol under origin of adipose fin, about 1,5 times its diameter below lateral line. Prc series arched, with Prc_3–Prc_4 interspace enlarged; Prc_4 about its own diameter below level of lateral line. A large luminous scale at PLO.

Maximum length 50 mm; sexually mature from about 31 mm.

Distribution

Indian Ocean: between 05°N and 12°S, but more common west of 75°E; south-east Asian seas. Pacific Ocean: central and western tropical waters to about 35°N in Kuroshio Current.

Remarks

The single, small, immature female (stage I, 26,6 mm), taken during the *Meiring Naude* cruises at 33°48,8′S 27°47,9′E, represents the first record of the species in the southern African region.

Diaphus luetkeni (Brauer, 1904)

Remarks

Although no sexually mature females were taken during the *Meiring Naude* cruises, stage IV females are known from as far south as 34°S off the east coast of South Africa.

Diaphus metopoclampus (Cocco, 1829)

Remarks

All female specimens taken during the *Meiring Naude* cruises were immature, but stage IV females are known from 25°55′S 39°30′E. The *Meiring Naude* specimens showed both subdivided and continuous Vn organs, but in all cases the PLO was nearer to the lateral line. Hulley (1981) has pointed out that GR_u counts in specimens from the North Atlantic tend to be higher than those from the South Atlantic. A comparison of this count between specimens from the western South Indian Ocean and those from the North Atlantic revealed a significant difference (t −4,20; df 58), while differences in GR_u count between specimens from the western South Indian Ocean and those from the South Atlantic were insignificant (t −2,38; df 85).

Diaphus mollis Tåning, 1928

Remarks

Hulley (1981) has pointed out that in the Atlantic the species apparently does not reach sexual maturity south of about 36°S (western sector) and about 25°S (eastern sector). SAM data indicate that sexually mature females (stage V) have been taken at 26°40′S 40°00′E, and stage IV females from as far south as 37°30′S in the region of 40°E.

Diaphus nielseni Nafpaktitis, 1978

Fig. 7

Diaphus nielseni Nafpaktitis, 1978: 17, figs 12–13 (06°37′N 122°24′E). Gjøsaeter & Beck, 1981: 257, 259, fig. 4.

Description

D 15 (14); A 14 (13); P 10; AO 6 + 5, total 11; GR 6 + 1 + 14, total 21.

Origin of dorsal fin about above base of ventral fin. Origin of anal fin behind end of base of dorsal fin. Origin of adipose fin on vertical through base of

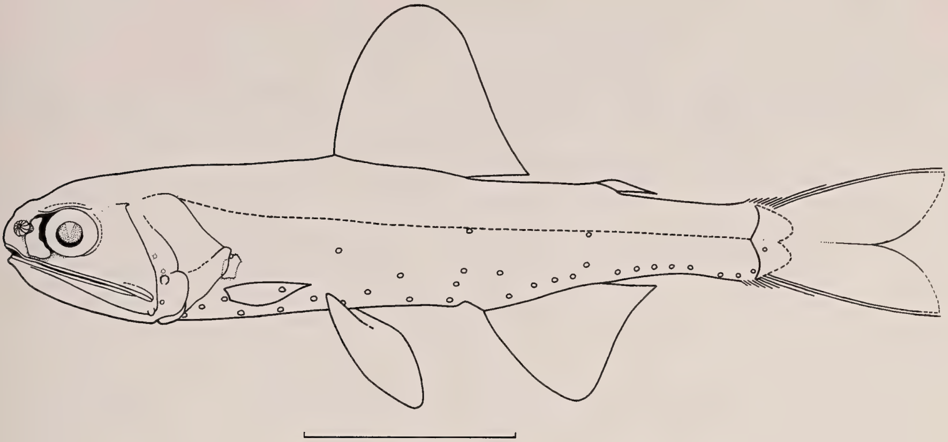

Fig. 7. *Diaphus nielseni* (SM 148). Scale 10 mm.

last anal ray or slightly in front of this vertical. Pectoral fin not reaching ventral base; ventral fin extending almost to origin of anal fin.

Dn heart-shaped and directed anterolaterally, slightly larger than general body photophore; Vn continuous with Dn, expanded posteroventrad to nasal rosette and extending posteriorly to about middle of anterior rim of iris. PLO about 1,5 times nearer to upper base of pectoral fin than to lateral line. VLO slightly nearer to lateral line than to base of ventral fin. SAO series slightly angulate, with SAO_1 above level of VO_2 and just posterior to VO_5, with SAO_2 about above anus and behind line joining centres of SAO_1 and SAO_3, and with SAO_3 in advance of vertical through origin of anal fin and in contact with lateral line. AOa^1 abruptly and highly elevated to about level of SAO_2; AOa^2–AOa^3 interspace enlarged; last AOa elevated; AOp behind end of base of anal fin, evenly spaced and level. Pol slighly in advance of origin of adipose fin and in contact with lateral line. Prc series widely spaced, with Prc_3–Prc_4 interspace subequal to AOp–Prc_1 interspace; Prc_4 about one photophore diameter below level of lateral line. A large, luminous scale at PLO.

Maximum length 40 mm; sexually mature from about 32 mm.

Distribution

High-oceanic, mesopelagic. Indian Ocean: Equatorial waters west of Sumatra; off east coast of Africa and in Mozambique Channel between 15°S and 21°S. Pacific: south-eastern Asian seas, northward to southern Japan.

Remarks

The *Meiring Naude* specimens represent the first record of the species in the southern African region, where there is a range extension to about 30°S. The three specimens are all immature.

Diaphus parri Tåning, 1932

Remarks

No sexually mature specimens were taken by the *Meiring Naude*.

Diaphus perspicillatus (Ogilby, 1898)

Remarks

No sexually mature specimens were taken by the *Meiring Naude*.

Diaphus problematicus Parr, 1928

Remarks

The single male specimen taken by the *Meiring Naude* represents a range extension to about 30°S in the western South Indian Ocean.

Diaphus splendidus (Brauer, 1904)

Remarks

No sexually mature specimens were taken by the *Meiring Naude*. The species is now known to extend southward to about 31°S off the east coast of South Africa.

Diogenichthys atlanticus (Tåning, 1928)

Fig. 8

Remarks

One female specimen (17,7 mm, stage IV) was taken by the *Meiring Naude*. *D. atlanticus* appears to be less common than *D. panurgus* off the South African east coast; the two species were however taken in the same hauls during the sampling.

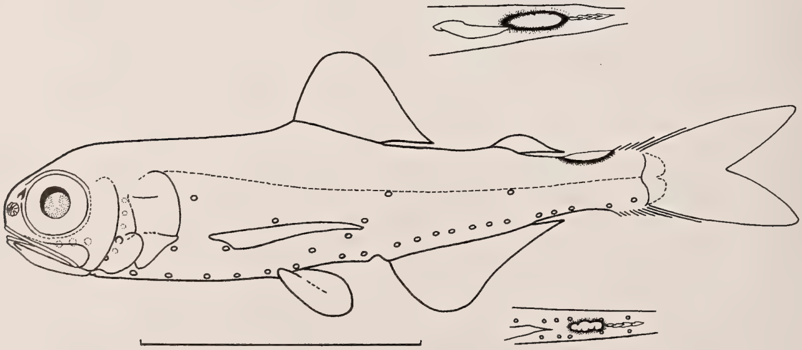

Fig. 8. *Diogenichthys atlanticus* (A 3634), with dorsal view of supracaudal luminous gland (♂) and ventral view of infracaudal luminous gland (♀). Scale 10 mm.

Diogenichthys panurgus Bolin, 1946

Fig. 9

Diogenichthys panurgus Bolin, 1946: 140 (05°56′N 76°22′E). Nafpaktitis & Nafpaktitis, 1969: 14, figs 13–15. Kotthaus, 1972*b*: 15, figs 264, 282. Wisner, 1976: 47. Parin *et al.*, 1977: 109, fig. 15.

Description

D 12 (rarely 10); A 16 (15, rarely 17); P 11 (10); AO 6 (5–7) + 3 (2), total 8–9 (10); GR 2 + 1 + 8–9, total 11–12. One specimen with GR 3 + 1 + 10, total 14 (left side), GR 2 + 1 + 9, total 12 (right side).

UJ 4,9–7,1 (mean 5,8) in SL; UJ 1,5–2,2 (mean 1,8) in HL.

Origin of dorsal fin behind vertical through ventral base; origin of anal fin on or in advance of vertical through base of last dorsal ray. Adipose origin well in advance of vertical through base of last anal ray. Pectoral fin extending to about anal origin; ventral fin extending to about VO_4.

Dn present, sexually dimorphic in mature males; Vn absent. Op_1 small, opposite expanded posterior margin of maxilla; Op_2 somewhat posterior to Op_1, below level of vental margin of orbit. 5 PO, evenly spaced and level. PVO_1 about above PO_2–PO_3 interspace and slightly below level of PVO_2, which is at lower base of pectoral fin. PLO about midway between upper pectoral base and lateral line. 4 VO, evenly spaced, with VO_2 elevated. VLO slightly in advance of vertical through VO_1 and at about level of upper pectoral base. SAO series straight or slightly curved, with SAO_1 on or behind vertical through VO_4 and slightly below level of VLO, with SAO_2 above anus, and with SAO_3 behind vertical through anal origin and in contact with lateral line. AO level; no AOp

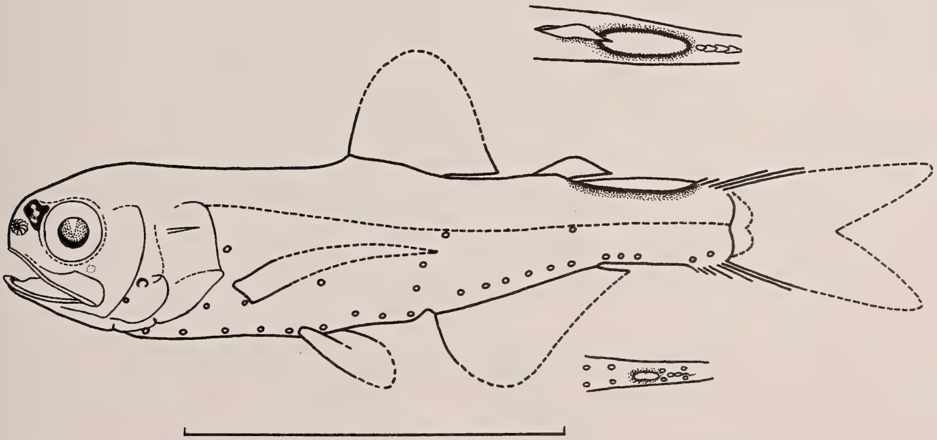

Fig. 9. *Diogenichthys panurgus* (SM 143D), with dorsal view of supracaudal luminous gland (♂) and ventral view of infracaudal luminous gland (♀). Scale 10 mm.

photophores above anal base. Pol well behind vertical through adipose origin and in contact with lateral line. Prc_2 slightly raised; Prc_1–Prc_2 interspace less than one-half distance AOp–Prc_1.

Mature males with single supracaudal gland only, extending from procurrent caudal rays almost to adipose base; females with infracaudal gland only, consisting of one coalesced or two partially-coalesced luminous patches.

Maximum length 23 mm; sexually mature from about 19 mm.

Distribution

High-oceanic, mesopelagic. Indian Ocean: 19°N to 05°S.

Remarks

The diagnostics of UJ in HL and in SL, as given by Nafpaktitis & Nafpaktitis (1969), do not appear to be valid in the *Meiring Naude* specimens. However, they have been identified as *D. panurgus* on the basis of GR count and the characters given by Kotthaus (1972*b*). As such, the specimens represent the first record of the species from the southern African region. During the cruises, the species was taken south to about 34°S, but additional SAM material suggests that it is found to as far south as 37°45′S in the region. Females with developing ovaries (stage III) have been taken to 31°S. The least depth of capture was 50–0 m.

Gonichthys barnesi Whitley, 1943

Remarks

Andriashev (1962) and Hulley (1981) have indicated that *G. barnesi* is taken in waters whose surface temperatures vary between 16 °C and 22 °C. The two *Meiring Naude* specimens were taken at the surface in temperatures of 23,03 °C and 23,68 °C. The single female (stage IV) was caught at 31°34′S.

Hygophum hanseni (Tåning, 1928)

Remarks

No sexually mature females were taken during the *Meiring Naude* cruises.

Hygophum hygomii (Lütken, 1892)

Remarks

Hulley (1981) recognizes two populations (northern and southern) in the Atlantic Ocean. There are no significant differences in meristics between specimens from the *Meiring Naude* cruises and those from the South Atlantic. As is the case with the latter, *Meiring Naude* specimens are significantly different to specimens from the North Atlantic in GR_I (t 5,89; df 128) and GR_T (t 6,23; df 128) counts. Stage V females were taken during the *Meiring Naude* cruises.

Hygophum proximum Bekker, 1965

Fig. 10

Myctophum (Myctophum) benoiti reinhardti Brauer, 1906: 185, fig. 97 (*partim*).
Hygophum reinhardtii (non Lütken) Sarenas, 1954: 418, fig. 12.
Hygophum benoiti (*non* Cocco) Blache, 1962: 33 (*partim*).
Hygophum proximum Bekker, 1965: 81, figs 6–9 (00°58′S 82°53′E). Nafpaktitis & Nafpaktitis, 1969: 17, figs 16–17. Kotthaus, 1972*b*: 16, figs 265, 268, pl. 1 (4). Parin *et al.*, 1977: 109, fig. 16. Gjøsaeter, 1981: 220.
Hygophum reinhardti (*non* Lütken) Grindley & Penrith, 1965: 282.

Description

D 14; A 19–20; P 13–14; AO 4–5 + 7, total 11–12; GR 4 + 1 + 13, total 18.

Origin of dorsal fin on vertical through outer ventral base; origin of anal fin on or slightly behind vertical through base of last dorsal ray. Origin of adipose fin well in advance of vertical through base of last anal ray. Pectoral fin extending to about anal origin; ventral fin reaching anal origin.

Dn and Vn present; small, luminous organ at posterior end of supraorbital ridge, slightly in advance of posterior margin of orbit. Op_1 opposite expanded posterior margin of maxilla; Op_2 about level of ventral margin of eye. 5 PO, level. PVO_1 in advance of vertical through PO_2, closer to level of ventral base of pectoral fin than to ventral profile; PVO_2 at lower base of pectoral fin. PLO midway between upper pectoral base and lateral line. VLO above outer base of ventral fin, closer to lateral line than to ventral base. 4 VO, level. SAO series obtusely angulate, with SAO_1 on or slightly in advance of vertical through VO_3, with SAO_2 about above anus; and with SAO_3 above origin of anal fin, in contact with lateral line. AOa and AOp level. 2 Pol with Pol_1 above last AOa and with Pol_2 well in advance of vertical through adipose origin. 2 Prc widely separated, with Prc_2 in contact with or less than one photophore diameter below lateral line.

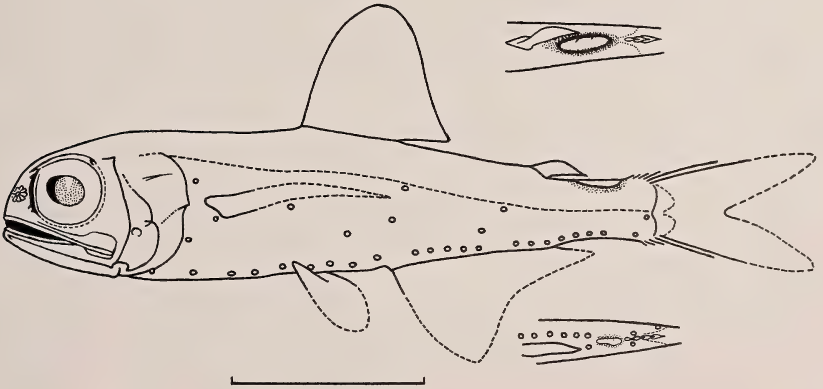

Fig. 10. *Hygophum proximum* (IK 35), with dorsal view of supracaudal luminous gland (♂) and ventral view of infracaudal luminous gland (♀). Scale 10 mm.

Males with single, black-edged supracaudal gland only; females with single infracaudal gland only.

Maximum length about 50 mm.

Distribution

High-oceanic, mesopelagic; nyctoepipelagic at the surface. Indian Ocean: 25°N to 10°S. Pacific Ocean: 24°N to 24°S (eastern sector).

Remarks

While the two *Meiring Naude* specimens (both immature) represent the first record of the species in the southern African region, specimens identified by Grindley & Penrith (1965) as *H. reinhardti* proved on re-examination to be *H. proximum*.

Lampadena luminosa (Garman, 1899)

Remarks

Both *Meiring Naude* specimens are immature.

Lampanyctus achirus Andriashev, 1962

Fig. 11

Lampanyctus ater (*non* Tåning) Norman, 1930: 331.

Lampanyctus achirus Andriashev, 1962: 256, fig. 27 (64°36′S 108°52′W). Nafpaktitis & Nafpaktitis, 1969: 54, figs 54–55 (*partim*). McGinnis, 1974: 143, fig. 34. Wisner, 1976: 176, figs 165–166 (*partim*). Hulley, 1981: 182, fig. 84.

[Non] Lampanyctus cf. *achirus*: Hulley, 1972: 225 (= *Lampanyctus* sp. B).

Description

D 15 (14); A 18 (17); AO 6–8 + 8 (7–9), total 14–16; GR (first arch) 5–6 + 1 + 12, total 18–19; GR_{I} (second arch) 1, x–xi; Ll 34–36.

Origin of dorsal fin well behind vertical through outer ventral base, with

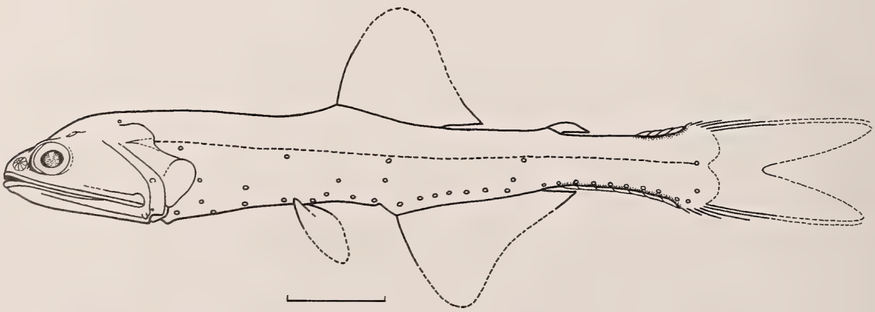

Fig. 11. *Lampanyctus achirus* (SM 187). Scale 10 mm.

Pre D 46–48% SL (mean 46,8 %); origin of anal fin about under middle of dorsal fin. Origin of adipose fin on or slightly behind vertical through last anal ray. Pectoral fins absent; ventral fins extending to about anus.

Dn absent; Vn small. Op_1 minute, at level of posterior margin of maxilla; Op_2 above Op_1, below level of ventral margin of eye. 5 PO, with PO_4 elevated and in front of, on or behind vertical through PO_3. PVO_1 midway between PO_1 and PO_2, or nearer PO_2 and at about level of posterior end of maxilla; PVO_2 about one photophore diameter below lateral line. VLO above outer ventral base or slightly in front, about one photophore diameter below lateral line. 4 VO, slightly arched, but VO_2 not anteriorly displaced to above VO_1; VO_1–VO_2 interspace shorter than rest of series. SAO series angulate, with SAO_1 above VO_2–VO_3 interspace and at about level of PO_4; with SAO_2 above anus or above origin of anal fin, equidistant between VO_4 and AOa^1, or closer to VO_4, and with SAO_3 at or slightly below lateral line. AO series straight or slightly arched, with AOa^1–AOa^2 interspace somewhat larger than interspaces of rest of series; AOp evenly spaced and level, no photophores above anal base. Pol_1 slightly behind vertical through last AOa; Pol_2 in advance of vertical through origin of adipose fin. 4 Prc, arched and with concavity directed anterodorsally; Prc_1 and Prc_2 level, or with Prc_2 lower; Prc_3 almost directly below Prc_4, which is situated at level of lateral line or above level.

Supracaudal gland consisting of 3–4 overlapping scales; infracaudal gland consisting of 7–8 overlapping scales, the first often separated from the rest of the series, extending 79–91% (mean 84,2%) of distance between procurrent caudal rays and base of last anal ray.

Maximum length 162 mm; sexually mature from about 133 mm.

Remarks

See under *Lampanyctus* sp. A (p. 83).

Lampanyctus ater Tåning, 1928

Fig. 12

Lampanyctus ater Tåning, 1928: 68 (24°30′N 80°00′W). Nafpaktitis & Nafpaktitis, 1969: 44, figs 53–54. Hulley, 1972: 225; 1981: 188, fig. 87. Nafpaktitis, 1973: 38, fig. 36. Wisner, 1976: 175, fig. 164. Nafpaktitis *et al.*, 1977: 203, figs 139, 141.
Lampanyctus niger (*non* Günther) Norman, 1930: 331 (*partim*). Fowler, 1936: 384 (*partim*).
Paralampanyctus ater Kotthaus, 1972*a*: 29, fig. 284, pl. 2 (12).

Description

D 15; A 19; AO 7+8, total 15; GR (first arch) 5+1+10, total 16; GR_1 (second arch) 1, ix; Ll 35–36.

Origin of dorsal fin well behind vertical through outer ventral base, with Pre D 46% SL; origin of anal fin below posterior third of dorsal fin. Origin of adipose fin well in advance of vertical through last anal ray. Pectoral fin small, probably extending only to PO$_3$; ventral fin reaching to VO$_4$.

Dn absent; Vn small. Op$_1$ minute, below level of posterior end of maxilla; Op$_2$ in advance of Op$_1$, at level of ventral margin of orbit. 5 PO, with PO$_4$ elevated and slightly behind vertical through PO$_3$. PVO$_1$ above PO$_1$–PO$_2$ interspace, closer to PO$_2$ and at about level of posterior end of maxilla; PVO$_2$ at upper pectoral base, in advance of vertical through PVO$_1$. PLO about three photophore diameters below lateral line. VLO above outer ventral base, about one photophore diameter below lateral line. 4 VO, evenly spaced and level. SAO series angulate, with SAO$_1$ midway between VO$_2$ and VO$_3$, with SAO$_2$ slightly in advance of anal origin, closer to VO$_4$ than AOa^1, and with SAO$_3$ behind origin of anal fin, in contact with lateral line. AOa more or less evenly spaced and slightly arched; AOp evenly spaced. Pol$_1$ behind vertical through last AOa; Pol$_2$ in contact with lateral line, behind vertical through adipose origin. Prc series arched, with concavity directed anterodorsally; with Prc$_2$ above level of Prc$_1$; with Prc$_3$ directly below Prc$_4$; and with Prc$_4$ above level of lateral line.

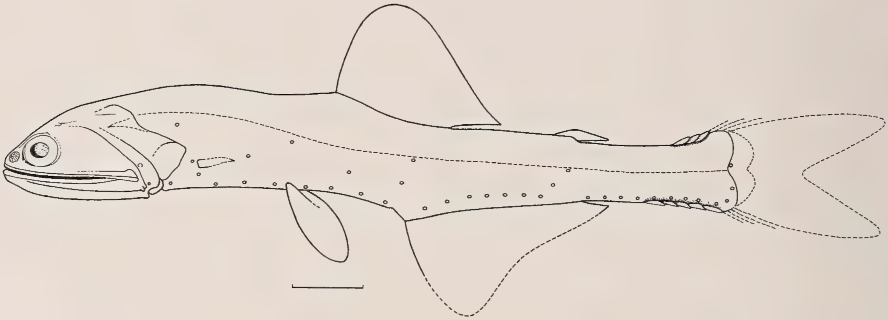

Fig. 12. *Lampanyctus ater* (SM 148). Scale 10 mm.

Supracaudal gland consisting of 3 overlapping scales; infracaudal gland consisting of 5 overlapping scales, extending 49% of distance between procurrent caudal rays and base of last anal ray.

Maximum length 129 mm; sexually mature from about 90 mm.

Distribution

High-oceanic, mesopelagic: day 680–1 200 m, exhibiting size stratification with depth; night 51–925 m, non-migrants all sizes. Atlantic Ocean: Subtropical Pattern (Bisubtropical Subpattern). Indian Ocean: 12°S to 44°S.

Remarks

See under *Lampanyctus* sp. A (p. 83).

Lampanyctus ?ater Tåning, 1928

Fig. 13

Description

D 15–16; A 17–18; P 12; AO 5+7 (8), total 12 (13); GR (first arch) 5+1+11, total 17; GR_I (second arch) 1, ix; Ll 32–33.

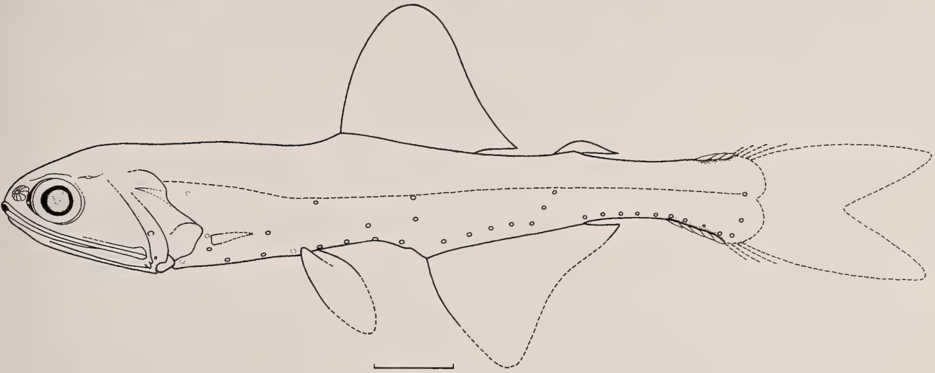

Fig. 13. *Lampanyctus ?ater* (SM 99). Scale 10 mm.

Origin of dorsal fin well behind vertical through outer ventral base, with Pre D 45–47% SL; origin of anal fin below posterior third of dorsal base. Origin of adipose fin well in advance of vertical through last anal ray. Pectoral fin weakly developed, probably extending to about PO_3; ventral fin reaching anus.

Dn absent; Vn small. Op_1 minute, below level of posterior margin of maxilla; Op_2 slightly in advance of Op_1, below level of ventral margin of orbit. 5 PO, with PO_4 elevated and slightly behind vertical through PO_3 or midway between PO_3 and PO_5. PVO_1 above PO_1–PO_2 interspace, closer to PO_2 and at level of posterior end of maxilla; PVO_2 above PO_1, at level of upper pectoral base. PLO about two photophore diameters below lateral line. VLO about above VO_1 and in contact with lateral line. SAO series angulate, with SAO_1 closer to VO_3 than to VO_2 and at level of PO_4, with SAO_2 above anus or anal origin, closer to VO_4 than to AOa^1, or equidistant, and with SAO_3 above anus or anal origin, in contact with lateral line. AOa evenly spaced and slightly arched; AOp level and not markedly separated from Prc series. Pol_1 behind vertical through last AOa; Pol_2 below origin of adipose fin, in contact with lateral line. Prc series arched, concavity directed anterodorsally; Prc_2 at about level of Prc_1; Prc_3 slightly in advance of vertical through Prc_4; and Prc_4 at lateral line.

Supracaudal gland consisting of 3 overlapping scales; infracaudal gland consisting of 4 overlapping scales, extending 46–49% of distance between procurrent caudal rays and base of last anal ray.

Remarks

The taxonomic status of these specimens is at present unclear and must await the publication of Zahuranec's (1980) thesis on the short-finned *Lampanyctus* species. The specimens most closely resemble *L. ater* and *Lampanyctus* sp. A in that the adipose origin is well in advance of the vertical through the base of the last anal ray, the Pol_2 is situated on the vertical through the adipose origin, and the infracaudal gland extends less than 60% of the distance between the procurrent caudal rays and the base of the last anal ray. While the lateral line counts suggest a similarity with those specimens identified as *Lampanyctus* sp. A, the AO_T, GR_T (first arch) and GR_l (second arch) indicate a closer affinity with *L. ater*.

Lampanyctus australis Tåning, 1932

Remarks

Stage IV females were taken by the *Meiring Naude* as far north as 28°S. SAM–27112 with 5 VO.

Lampanyctus festivus Tåning, 1928

Remarks

The three specimens taken by the *Meiring Naude* are immature.

Lampanyctus lepidolychnus Bekker, 1967

Remarks

Hulley (1981: 203) has given diagnostic characters for the separation of this species from *L. intricarius*. Among these is the fact that 'CPD is greater than HD' in *L. lepidolychnus*, where HD is measured on the vertical through the posterior end of the upper jaw. This is erroneous and should read 'CPD is greater than head depth as measured on the vertical through the middle of the orbit'. Specimens of *L. lepidolychnus* from the *Meiring Naude* cruises show the following variation in these two meristics: CPD 1,0–1,3 (mean 1,1) times in head depth, as measured on the vertical through the middle of the orbit; and CPD 0,7–0,8 (mean 0,7) times in HD (measured on the vertical through the posterior end of the upper jaw). The diagnostic 'CPL in UJ' varies 1,5–3,1 in *Meiring Naude* specimens, the values being negatively related to increasing SL. In view of the above, the most reliable character for the separation of *L. lepidolychnus* and *L. intricarius* is the length of the pectoral base in relation to the vertical distance between the lower margin of the orbit and the upper lip, measured at the middle of the orbit. Consequently, the lengths of the pectoral fins are also diagnostic, but these are often broken.

Lampanyctus nobilis Tåning, 1928

Remarks

The two *Meiring Naude* specimens are immature.

Lampanyctus pusillus (Johnson, 1890)

Remarks

The *Meiring Naude* material included only stage IV females; stage V females are known from the southern African east coast region (SAM data).

Lampanyctus turneri (Fowler, 1934)

Remarks

SAM–28064 with 5 VO on left side. Stage V females were taken by the *Meiring Naude* as far south as about 31°S. The least depth of capture during the cruises was 212–0 m.

Lampanyctus sp. A

Fig. 14

Description

D 14; A 18; P weakly developed; AO 5+6, total 11; GR (first arch) 4+1+10, total 15; GR_1 (second arch) 1, viii–ix; Ll 31–32.

Origin of dorsal fin well behind vertical through outer ventral base, with Pre D 48–49% SL; origin of anal fin below about middle of dorsal base. Origin of adipose fin well in front of vertical through base of last anal ray. Pectoral fin weakly developed, probably not extending beyond level of PO_3; ventral fin reaching to origin of anal fin.

Dn absent; Vn small. Op_1 minute, below level of posterior end of maxilla; Op_2 slightly posterior to Op_1, below level of ventral margin of orbit. 5 PO, with PO_4 elevated above level of upper pectoral base and behind vertical through PO_3. PVO_1 above PO_1–PO_2 interspace, closer to PO_2 than to PO_1 and at level of posterior end of maxilla; PVO_2 at level of upper pectoral base. PLO about two photophore diameters below lateral line. VLO above VO_1, in contact with lateral line. 4 VO, level, with VO_2–VO_3 interspace greatest. SAO series angulate, with SAO_1 closer to VO_3 than to VO_2 and at level of PO_4, with SAO_2 on or pos-

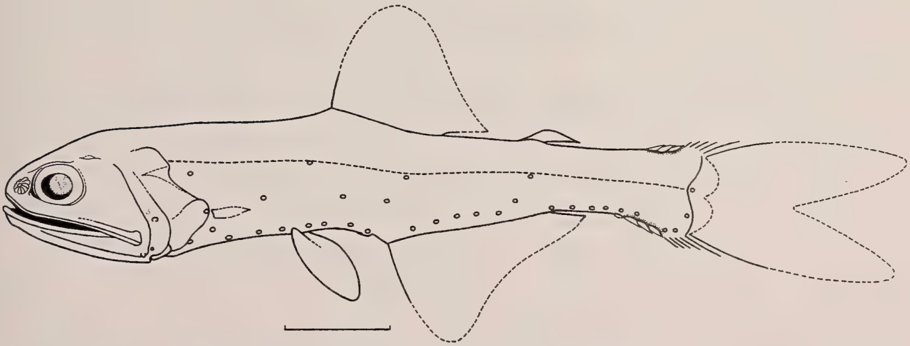

Fig. 14. *Lampanyctus* sp. A (SM 125). Scale 10 mm.

terior to vertical through anal origin, and with SAO_3 about above AOa^1 and in contact with lateral line. AOa series slightly arched; AOp series level and noticeably separated from Prc series. Pol_1 behind vertical through last AOa; Pol_2 on or behind vertical through origin of adipose fin and in contact with lateral line. Prc series arched, concavity directed anterodorsally; Prc_2 at level of Prc_1; Prc_3 slightly in advance of vertical through Prc_4; and Prc_4 at level of lateral line.

Supracaudal gland consisting of 3 overlapping luminous scales; infracaudal gland consisting of 4 overlapping scales, the first of which may be separated from the rest of the series, extending 46–48 % of distance between procurrent caudal rays and base of last anal ray.

Remarks

Due to the fact that the taxonomy of the short-finned *Lampanyctus* species is at present under review (Zahuranec 1980), specific names have not been given to the two specimens taken by the *Meiring Naude*. These specimens and *L. ater* differ from *L. achirus* and an as yet unnamed species (*Lampanyctus* sp. B), which is known from off the west coast of South Africa, in that the origin of the adipose fin is well in advance of the vertical through the base of the last anal ray. Consequently, the Pol_2 is situated on or behind the vertical through the adipose origin. Further, the infracaudal gland does not extend more than 55–60 % of the distance between the procurrent caudal rays and the base of the last anal ray (in the *L. achirus*-group extending 60–100 % of that distance). The specimens may be separated from *L. ater* by the fewer number of lateral line organs, the lower GR_T (first arch) count and the number of tooth patches on GR_l (second arch). *Lampanyctus* sp. B was not present in the *Meiring Naude* material.

Lobianchia dofleini (Zugmayer, 1911)

Remarks

No specimens larger than about 36 mm have been taken off the east coast (*Meiring Naude* and SAM data; Nafpaktitis 1978). Females are sexually mature (stage V) from about 34 mm in the southern African region.

Lobianchia gemellarii (Cocco, 1838)

Remarks

No sexually mature specimens were taken by the *Meiring Naude*, but SAM data indicate that stage IV specimens (49–58 mm) are known from the region. No specimens greater than about 56 mm are known from the western South Indian Ocean.

Myctophum asperum Richardson, 1845

Remarks

No sexually mature specimens were taken by the *Meiring Naude*. During these cruises, most specimens (78 %) were taken at the surface at night, at temperatures between 23,68 °C and 24,61 °C; the temperature at 200 m for all stations at which the species was taken varied between 13,10 °C and 16,75 °C.

Myctophum aurolaternatum Garman, 1899

Fig. 15

Myctophum aurolaternatum Garman, 1899: 264, pl. 55, fig. 3 (06°21'N 80°41'W). Brauer, 1906: 162. Sarenas, 1954: 390, fig. 4. Nafpaktitis & Nafpaktitis, 1969: 28, fig. 10. Kotthaus, 1972*b*: 23, figs 266, 283, pl. 1 (5). Kawaguchi & Aioi, 1972: 167, figs 5–6. Kawaguchi *et al.*, 1972: 28, fig. 10. Hartmann & Clarke, 1975: 365. Wisner, 1976: 54, fig. 47. Parin *et al.*, 1977: 111. Gjøsaeter, 1981: 220. Gjøsaeter & Beck, 1981: 257.

Description

D 14; A 24; P 15; AO 10 (11) + 7, total 17 (18); GR 5 (4) + 1 + 11 (12), total 17.

Origin of dorsal fin behind vertical through outer ventral base; origin of anal fin slightly behind vertical through base of last dorsal ray. Origin of adipose fin in advance of vertical through base of last anal ray. Pectoral fin reaching to level of VO$_2$ or VO$_3$; ventral fin extending almost to origin of anal fin. Posterodorsal margin of operculum serrate. Scales cycloid.

Dn and Vn small. Op$_1$ opposite posterior end of maxilla; Op$_2$ above Op$_1$, at level of ventral margin of orbit. PLO midway between lateral line and upper base of pectoral fin or closer to upper pectoral base. 5 PO, evenly spaced and level. PVO$_1$ above PO$_2$ and slightly above level of Op$_1$; PVO$_2$ at lower pectoral base. 4 VO, evenly spaced and level. SAO series straight, with SAO$_1$ directly above VO$_4$, with SAO$_2$ above anus, and with SAO$_3$ above or slightly behind vertical through anal origin and in contact with lateral line. AOa series level; AOp^1 above anal base. Pol well in advance of vertical through adipose origin, above last AOa and in contact with lateral line. 2 Prc, less than one photophore diameter apart and with Prc$_2$ raised.

Maximum length 105 mm.

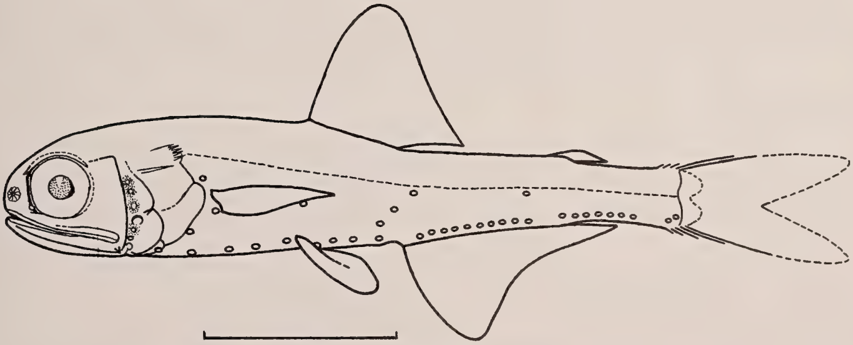

Fig. 15. *Myctophum aurolaternatum* (SM 95N). Scale 10 mm.

Distribution

High-oceanic, mesopelagic: nyctoepipelagic at the surface and down to 200 m. Indian Ocean: (western sector) Zanzibar to Gulf of Aden, including Sofala Bank; (eastern sector) 05°S to 18°S; south-eastern Asian seas; Pacific Ocean: western, central and eastern Equatorial regions.

Remarks

The three specimens, all immature, which were taken at the surface and down to 212 m by the *Meiring Naude*, represent the first record of the species in the southern African region.

Myctophum phengodes (Lütken, 1892)

Remarks

No sexually mature specimens were taken by the *Meiring Naude*. Surface temperatures at the capture stations varied between 22,92 °C and 24,40 °C, and would substantiate the 15 °C and 25 °C surface isotherm limits for the distribution of the species (Hulley 1981).

Myctophum spinosum (Steindachner, 1867)

Remarks

No sexually mature specimens were taken by the *Meiring Naude*.

Notolychnus valdiviae (Brauer, 1904)

Remarks

No sexually mature specimens were taken by the *Meiring Naude*.

Notoscopelus (Notoscopelus) caudispinosus (Johnson, 1863)

Fig. 16

Scopelus caudispinosus Johnson, 1863: 42 (off Madeira).
Notoscopelus elongatus (*non* Costa) Grindley & Penrith, 1965: 283 (*partim*).
Notoscopelus caudispinosus: Nafpaktitis & Nafpaktitis, 1969: 66, figs 38, 40. Parin *et al.*, 1977: 128, fig. 21.
Notoscopelus (Notoscopelus) caudispinosus Nafpaktitis, 1975: 76, figs 1–2. Nafpaktitis *et al.*, 1977: 248, figs 173–174. Hulley, 1981: 243, fig. 116.

Description

D 27; A 20–21; P 12; AO 7 + 4 (5), total 11 (12); GR 4 + 1 + 9, total 14.

Origin of dorsal fin slightly behind vertical through outer ventral base; origin of anal fin below about middle of dorsal base. Origin of adipose fin slightly in front of vertical through last anal ray. Pectoral fin reaching to ventral base; ventral fin reaching to about anus.

Dn and Vn present. Op_1 more or less opposite posterior end of maxilla; Op_2 above Op_1, below level of ventral margin of orbit. 5 PO, level, with PO_1–PO_2 interspace greatest. PVO_1 at lower pectoral base; PVO_2 above upper pectoral

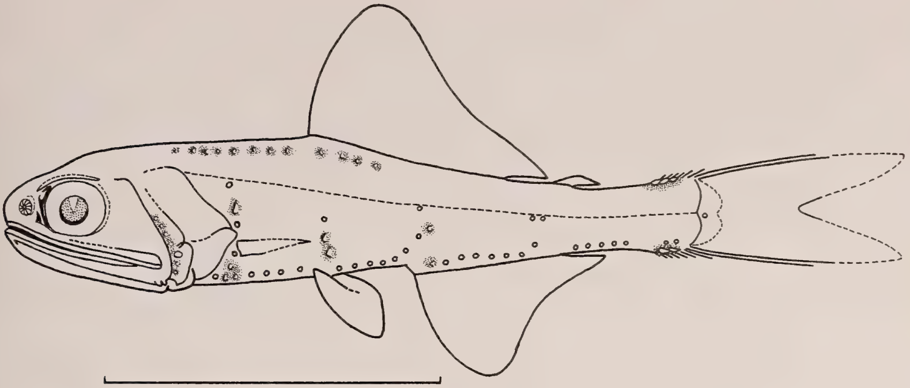

Fig. 16. *Notoscopelus (Notoscopelus) caudispinosus* (SM 189D). Scale 10 mm.

base. PLO immediately below lateral line. 5 VO, evenly spaced, with VO_5 sometimes distinctly raised. VLO above ventral base, midway between ventral base and lateral line. SAO series obtusely angulate, with SAO_1 about two photophore diameters posterodorsad to VO_5, with SAO_2 above anal origin, and with SAO_3 about on vertical through SAO_2 and in contact with lateral line. 2 Pol, horizontal, immediately below lateral line and in advance of vertical through adipose origin. 3 Prc; with Prc_2 about one photophore diameter behind Prc_1 and level with it; and with Prc_3 about one photophore diameter below level of lateral line. Luminous tissue on nape and below anterior part of dorsal fin; between PLO and PVO_2; in region of PO_1, PVO_1, PO_2; between VLO and ventral base; in region of SAO series and AOa^1; and below ventral procurrent caudal rays.

Maximum length 140 mm.

Distribution

High-oceanic, mesopelagic: day, deeper than 1 000 m; nyctoepipelagic at surface and down to 175 m. Atlantic Ocean: Broadly Tropical Pattern (Holo-eurytropical Subpattern). Indian Ocean: 07°56′S 65°14′E. South-eastern Asian seas. Pacific Ocean: off Hawaii.

Remarks

The *Meiring Naude* specimens, all immature, represent the first record of the species in the southern African region, with the shallowest depth of capture being 212–0 m.

Notoscopelus (Notoscopelus) resplendens (Richardson, 1845)

Remarks

Stage V females were taken in the region by the *Meiring Naude*.

Symbolophorus evermanni (Gilbert, 1905)

Fig. 17

Myctophum evermanni Gilbert, 1905: 597 (south of Oahu, Hawaii).
Symbolophorus evermanni: Nafpaktitis & Nafpaktitis, 1969: 29, figs 30–31. Kotthaus, 1972*b*: 26, figs 270, 283, pl. 1 (2). Wisner, 1976: 50, figs 44–45. Parin *et al.*, 1977: 110. Gjøsaeter, 1981: 220, fig. 19. Gjøsaeter & Beck, 1981: 257.

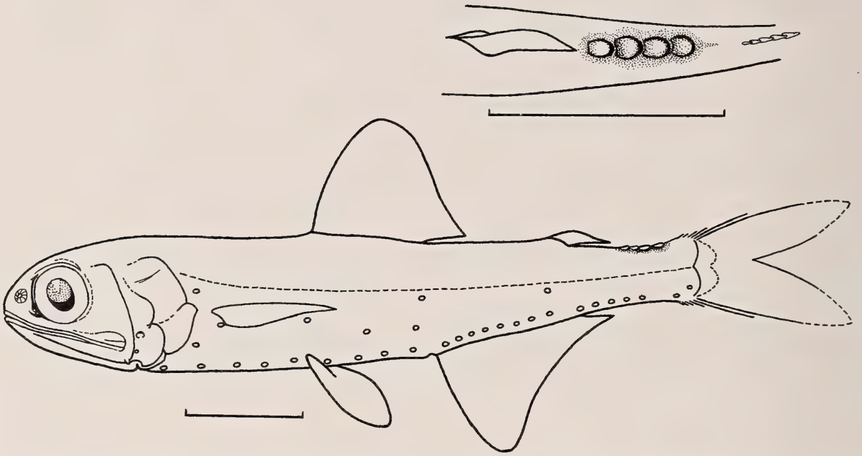

Fig. 17. *Symbolophorus evermanni* (SM 63), with dorsal view of supracaudal luminous gland (♂). Scales 10 mm.

Description

D 14–15 (13–16); A 20 (19–21); P 14–15 (16); AO 8 (7–9) + 5 (4–6), total 13 (12–14); GR 5 (6) + 1 + 14 (13), total 20 (19–21). One specimen (SAM–29087) with two SAO_1 photophores on left side.

Origin of dorsal fin above ventral base; origin of anal fin behind vertical through base of last dorsal ray. Origin of adipose fin well in advance of vertical through base of last anal ray. Pectoral fin extending to midway between VLO and SAO_1 or to level of SAO_1; ventral fin extending to about VO_4.

Dn and Vn present. Op_1 opposite posterior end of maxilla; Op_2 above Op_1, below level of ventral margin of orbit. 5 PO, evenly spaced and level. PVO_1 slightly in advance of vertical through PO_2 and below level of Op_2; PVO_2 at lower pectoral base. PLO two or more photophore diameters below lateral line. VLO on or slightly in advance of vertical through outer ventral base, nearer to lateral line than to ventral base. 4 VO, evenly spaced and level. SAO series angulate, with SAO_1 on vertical through VO_2 or closer to VO_2 than VO_3 and about equidistant between SAO_2 and VLO, with SAO_2 slightly behind vertical through VO_4 and at level of SAO_1, and with SAO_3 above anus, about one photophore diameter or less below lateral line. AOa evenly spaced and level; AOp evenly spaced and level, usually with AOp^1 above anal base. Pol on vertical through adipose origin. Prc_2 about one and half photophore diameters behind Prc_1 and elevated.

Males with 4–6 overlapping, luminous scales supracaudally.

Maximum length 80 mm.

Distribution

High-oceanic, mesopelagic: nyctoepipelagic at surface at night. Tropical waters of Indo-Pacific Ocean.

Remarks

The specimens represent the first record of the species in the southern African region. No sexually mature females were taken by the *Meiring Naude*.

Taaningichthys bathyphilus (Tåning, 1928)

Fig. 18

Lampadena bathyphilus Tåning, 1928: 63 (25°11′N 20°57′W).

Taaningichthys bathyphilus: Nafpaktitis & Paxton, 1968: fig. 10 (9). Davy, 1972: 70, figs 3, 5, 6B, 6D. Nafpaktitis, 1973: 38, fig. 35. McGinnis, 1974: 133, figs 30, 58. Wisner, 1976: 145, figs 131–132. Parin *et al.*, 1977: 122. Nafpaktitis *et al.*, 1977: 189, figs 127–128. Hulley, 1981: 168, fig. 77.

Description

D 13; A 13 (12); P 13 (12); AO 2–3 + 1, total 4; GR 3 (4) + 1 + 7, total 11 (12).

Origin of dorsal fin well behind vertical through outer base of ventral fin; origin of anal fin well behind vertical through base of last dorsal ray. Origin of adipose fin on vertical through base of last anal ray. Pectoral fin extending to base of ventral fins; ventral fin reaching to about anus. Crescent of whitish tissue on posterior half of iris.

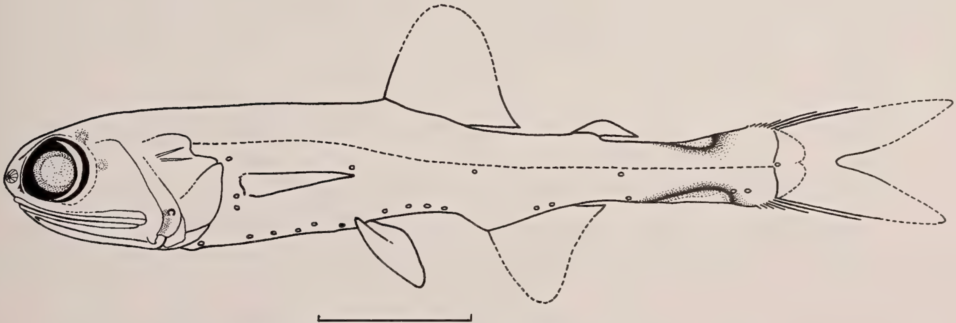

Fig. 18. *Taaningichthys bathyphilus* (SM 138). Scale 10 mm.

Dn absent; Vn present. Op_2 opposite posterior end of maxilla. 6 PO, with PO_1–PO_2 interspace greatest. PVO_1 above PO_1–PO_2 interspace, closer to PO_2 than to PO_1 and below level of ventral margin of orbit; PVO_2 directly above PVO_1, at level of lower pectoral base. PLO closer to horizontal septum than to upper pectoral base. VLO above ventral base, closer to horizontal septum than to ventral base. VO series level. SAO behind vertical through last VO and about one photophore diameter below horizontal septum. AOa well behind origin of anal fin; AOp in front of infracaudal gland. Pol well behind base of adipose fin, about one photophore diameter below horizontal septum. Prc_1, Prc_2 about one photophore diameter apart; Prc_3 at level of horizontal septum.

Supracaudal gland black-edged, occupying about 30 % of distance between procurrent caudal rays and base of adipose fin; infracaudal gland larger, occupying about 50 % or more of distance between procurrent caudal rays and base of anal fin.

Maximum length 80 mm; sexually mature from about 57 to 61 mm.

Distribution

High-oceanic, bathypelagic: generally below about 700 m, but with shallowest depth of capture at 400 m. Widespread pattern in all three oceans, generally between about 43°N and 68°S.

Remarks

The *Meiring Naude* specimens represent the first record of the species in the southern African region. One female specimen (SAM–28090) at stage III.

Triphoturus nigrescens (Brauer, 1904)

Fig. 19

Myctophum (Lampanyctus) nigrescens Brauer, 1904: 403 (03°24′06″S 58°38′01″E); 1906: 241, fig. 158.
Myctophum (Lampanyctus) micropterum Brauer, 1906: 239, fig. 157 (*partim*).
Lampanyctus microchir Gilbert, 1913: 101 (Suruga Bay, Japan).
Triphoturus microchir: Nafpaktitis & Nafpaktitis, 1969: 55, figs 62, 70. Kotthaus, 1972*b*: 29, fig. 284. Clarke, 1973: 406, fig. 12. Hartmann & Clarke, 1975: 636. Parin *et al.*, 1977: 125.
Triphoturus nigrescens: Wisner, 1976: 165, fig. 155.

Description

D 14 (13–15); A 16–17 (15–18); P 8; AO 4–5 + 6 (5), total 10–11; GR 3 + 1 + 8 (7), total 12 (11).

Origin of dorsal fin well behind vertical through ventral base; origin of anal fin under middle of dorsal base or slightly more anterior. Origin of adipose fin on vertical through base of last anal ray. Pectoral fin reaching to about PO_4; ventral fin extending slightly posterior to VO_4.

Dn absent; Vn present. Op_1 low down, at about level of PO_1; Op_2 well below level of ventral margin of orbit. 5 PO, with PO_1–PO_2 interspace greatest

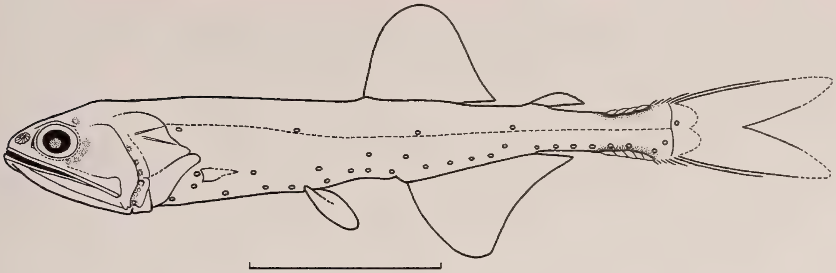

Fig. 19. *Triphoturus nigrescens* (SM 157). Scale 10 mm.

and with PO_4 elevated and anteriorly displaced to directly on, anterior to or behind vertical through PO_3 and at level of upper pectoral base or slightly higher. PVO_1 above PO_1–PO_2 interspace, closer to PO_1 than to PO_2 and at about level of Op_2; PVO_2 on or slightly behind vertical through PVO_1 and below level of upper pectoral base. PLO well in advance of vertical through upper pectoral base, at or less than one photophore diameter below lateral line. 5 VO, with VO_2 elevated and anteriorly displaced to before VO_1. SAO angulate, with SAO_1 nearer to VO_3, above VO_3–VO_4 interspace or above VO_4 and at level of ventral margin of orbit, with SAO_2 above anal origin and at level of SAO_1, and with SAO_3 behind vertical through anal origin and touching lateral line. AOa level, with AOa^1—AOa^2 interspace greatest; AOp level. 2 Pol, with Pol_1 behind last AOa and with Pol_2 in advance of vertical through adipose origin and touching lateral line. 3 Prc, in straight ascending line, with Prc_2 nearer to Prc_1 and touching line through centres of Prc_1 and Prc_3, or slightly below this line; Prc_3 above level of lateral line.

Supracaudal gland with 4 overlapping, luminous scales; infracaudal gland with 5 overlapping, luminous scales.

Maximum length 40 mm.

Distribution

High-oceanic, mesopelagic: in upper 24 m at night. Indian Ocean: 08°N to 15°S. Pacific Ocean: 30°N to 30°S (but see *Remarks*).

Remarks

No sexually mature specimens were taken during the *Meiring Naude* cruises.

The taxonomic status of species of the genus *Triphoturus* in the Indo-Pacific is at present unresolved. Hulley (1981) has pointed out that the type series of *Myctophum (Lampanyctus) micropterum* Brauer, 1906, comprises two species: *Lampanyctus isaacsi* Wisner, 1974 (ZMB 17614, 17615—Gulf of Guinea) and *Triphoturus micropterus* (ZMB 17616—east of Seychelles), and for the purposes of stability has designated the latter specimen as the lectotype of *T. micropterus*.

Further, he finds no differences between this lectotype and the descriptions of *T. microchir* (Gilbert) given by Gilbert (1913) and by Nafpaktitis & Nafpaktitis (1969). Accordingly, he has synonymized *T. microchir* with *T. micropterus*.

On the other hand, Wisner (1976) has synonymized *T. microchir* (Gilbert) with *T. nigrescens* (Brauer), as there appear to be no differences warranting the retention of Gilbert's species. This would suggest, therefore, that *T. nigrescens, T. micropterus* and *T. microchir* may all be synonyms, with *T. nigrescens* having priority. Until a fuller investigation can be carried out, this synonymy is followed in the present paper.

DISCUSSION

The relatively low numbers of myctophids taken during the *Meiring Naude* cruises are indicative of both the types of gear employed and its deployment at night at fishing depths below the major concentrations of lantern-fishes. The IKMT and RMT were fished at 12 stations in depths of 400 m or less, of which only 10 were occupied after sundown, and at 47 stations in depths greater than 400 m, of which 22 were occupied during daylight hours (Louw 1977, 1980). These facts, coupled to the limited sampling both in geographic extent (*c*. 27°S–34°S) and in seasonality (May–June), severely restrict the potential for zoogeographic analysis of the data. Hulley (1981) has pointed out that in such an analysis ecological differences should be distinguished, so that the distribution patterns of oceanic species (both mesopelagic and bathypelagic) and pseudoceanic species (with pelagic and epibenthic modes of life) may be separately compared. Johnson (1982) has reviewed the papers covering Indian Ocean zoogeography and recognizes five groups of species for the families Scopelarchidae and Evermannellidae, namely Transition Region Species (= Convergence Species), Subtropical Species, Tropical–Subtropical Species (= Broadly Tropical Species), Tropical Species, and Species Occurring North of 10°N.

Although two pseudoceanic species are known from the western South Indian Ocean, only the pelagic species *Diaphus garmani* was taken during the *Meiring Naude* cruises. In the Atlantic this species is restricted to the western provinces, with a southern limit at about 10°S in the Amazonian Region (Hulley 1981), probably due to the lens of high temperature, high salinity, and low productivity water off the north-east coast of Brazil. *D. garmani* appears to be more widespread in the Indo-Pacific (Nafpaktitis 1978: fig. 9; Kawaguchi & Shimizu 1978: fig. 54) and, due to the absence of an equivalent gyral lens, extends to about 31°S in the southern African region. The epibenthic species *Diaphus watasei* is known from the Mozambique Channel (Gjøsaeter & Beck 1981) and has now been recorded from as far south as 30°05′S 31°05′E in 366–0 m (SAM data).

Two bathypelagic species, *Taaningichthys bathyphilus* (Widespread Pattern) and *Lampanyctus achirus* (South Temperate Pattern: Subantarctic Subpattern), were taken by the *Meiring Naude. T. bathyphilus* occurred at three stations with fishing depths of 750–0 m, 830–0 m and 916–0 m respectively, but only at the latter station were temperature data below 250 m available. Here, the upper 600 m was warmer than 10,5 °C, but a temperature of less than 5,68 °C was recorded at 800 m and below. *Lampanyctus achirus* occurs northward to the position of the Subtropical Convergence in the western sector of the South Atlantic (Hulley 1981), but data from the *Meiring Naude* cruises indicate that it may be taken as far north as 31°S in the western South Indian Ocean. This is well to the north of the Subtropical Convergence as drawn by Deacon (1937), and is no doubt due to the influence of cold Antarctic Intermediate Water, which underlies the core of the Agulhas Current, especially along its western boundary (De Decker & Mombeck 1965; Carter 1977).

This same water mass and its associated upwelling phenomena (Carter 1977) can also be correlated with the occurrence of cold water mesopelagic species off the east coast. The subantarctic species *Diaphus hudsoni* was taken north to about 27°S, while the Convergence Subpattern species (*Hygophum hanseni, Gonichthys barnesi*, and *Lampadena notialis*) apparently have a northern limit at about 30°S. The deeper-living convergence species *Lampanyctus australis* and *Lampanyctus lepidolychnus* were taken throughout the sampling area, as were the temperate species *Diaphus metopoclampus* (recorded to north of the Equator—Nafpaktatis 1978) and *Lampadena speculigera*.

Apart from *Taaningichthys bathyphilus*, all new records for the southern African region are species that have a tropical-subtropical distribution and specimens that may be actively transported into the region (? as expatriates) by the Agulhas Current. Five of these species (*Benthosema fibulatum, Diaphus aliciae, Hygophum proximum, Myctophum aurolaternatum*, and *M. obtusirostre*) were taken only in Bongo hauls or neuston tows, while 68,7% and 82,6% of the specimens of *Diogenichthys panurgus* and *Symbolophorus evermanni* respectively were obtained from these gears. Further, the new records of species taken at IKMT and RMT stations (*Diaphus jenseni, D. nielseni, D. problematicus*, and *Notoscopelus caudispinosus*) and records of *Triphoturus nigrescens*, from both RMT (64,7%) and Bongo (35,3%) nets consist mainly of juvenile specimens. This suggests, therefore, that distributional ranges of the breeding populations should be thoroughly investigated before any attempt at pattern analysis is made. Unfortunately the data at hand do not allow for this.

Pooled data from the *Meiring Naude* and other cruises at the South African Museum reveal that, except for *Diaphus effulgens* and *Myctophum phengodes*, stage IV and stage V females of the following subtropical species have been taken off the east coast of South Africa: *Hygophum hygomii, Lampanyctus ater, L. pusillus, Bolinichthys indicus, Symbolophorus barnardi*, and *Scopelopsis multipunctatus*. Stage IV and stage V females of the following tropical or broadly tropical species have been recorded from the region: *Benthosema suborbitale, Diaphus brachycephalus, D. diadematus, D. luetkeni, D. mollis, D. richardsoni, Diogenichthys panurgus, Hygophum proximum, Lampanyctus alatus, L. turneri, Lobianchia dofleini, L. gemellarii*, and *Notoscopelus resplendens*.

ACKNOWLEDGEMENTS

My thanks are due to Captain G. Foulis and the crew of the R.V. *Meiring Naude*; to my scientific colleagues on these cruises; to Mr V. Branco for preparation of the final drawings; and particularly to Mr Sidney Kannemeyer (South African Museum) for assistance with sorting and photography. I should like to express my gratitude to Dr G. Krefft (Hamburg) for his critical comments.

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Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family **Nuculanidae**

Nuculana (*Lembulus*) *bicuspidata* (Gould, 1845)

Figs 14–15A

Nucula (*Leda*) *bicuspidata* Gould, 1845: 37.
Leda plicifera A. Adams, 1856: 50.
Laeda bicuspidata Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).
Nucula largillierti Philippi, 1861: 87.
Leda bicuspidata: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

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(continued inside back cover)

ANNALS OF THE SOUTH AFRICAN MUSEUM
ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

Volume **93** Band
February **1984** Februarie
Part **3** Deel

MID-CRETACEOUS OSTRACODA FROM SOUTHERN AFRICA AND THE FALKLAND PLATEAU

By

R. V. DINGLE

Cape Town Kaapstad

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Verkrygbaar van die Suid-Afrikaanse Museum, Posbus 61, Kaapstad 8000

OUT OF PRINT/UIT DRUK

1, 2(1–3, 5–8), 3(1–2, 4–5, 8, t.–p.i.), 5(1–3, 5, 7–9),
6(1, t.–p.i.). 7(1–4), 8, 9(1–2, 7), 10(1–3),
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Kopieregnavrae aan die Suid-Afrikaanse Museum

ISBN 0 86813 051 6

Printed in South Africa by
The Rustica Press, Pty., Ltd.,
Court Road, Wynberg, Cape

In Suid-Afrika gedruk deur
Die Rustica-pers, Edms., Bpk.,
Courtweg, Wynberg, Kaap

MID-CRETACEOUS OSTRACODA FROM SOUTHERN AFRICA AND THE FALKLAND PLATEAU

By

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Marine Geoscience Unit, Department of Geology,
University of Cape Town

(With 42 figures and 14 tables)

[*MS accepted 10 August 1983*]

ABSTRACT

Fifty-one species, representing 26 genera are recorded from the Aptian to Cenomanian strata of Zululand, the Agulhas Bank, and the Falkland Plateau (DSDP sites 327 and 330); 35 of the species are new, 10 have previously been described from south-east and east Africa, and Australia, and 6 are left in open nomenclature; 2 new genera (*Makatinella* and *Pongolacythere*), and 1 new subgenus *Hemingwayella (Parahemingwayella)* are erected; 25 new species are formally described: *Cytherella bensoni, Cytherelloidea makatiniensis, C. ndumuensis, Robsoniella falklandensis, Pariceratina liebaui, Cytherura? oertlii, Eucytherura rugosa, E. stellifera, Procytherura batei, Cytheropteron bispinosa, Hemingwayella (Parahemingwayella) barkeri, H. (P.) dalzieli, H. (P.) reticulata, Hemiparacytheridea ewingensis, H. challengeri, Pedicythere falklandensis, Pongolacythere striata, Collisarboris? stanleyensis, Isocythereis? ndumuensis, Makatinella tritumida, M. inflata, Pirileberis makatiniensis, P. mkuzensis, Asciocythere? dubia,* and *Aitkenicythere? striosulcata*.

The marine benthic ostracod faunas of south-east Africa and the Falkland Plateau are compared and contrasted in the context of mid-Cretaceous palaeogeographic refits of south-western Gondwanaland, and Callovian to Aptian (Fauna A) and Albian to Cenomanian (Fauna B) associations are recognized in the South Gondwana ostracod province. Strong Albian faunal links existed between south-east Africa and the Falkland Plateau, which support refits that place the two areas in juxtaposition in Lower Cretaceous times. Environments of deposition are investigated, and water depths of *c*. 200 m and 200–<100 m are postulated for the Falkland Plateau sites and Zululand, respectively.

CONTENTS

PAGE
Introduction 98
  Zululand 99
  Falkland Plateau 105
  Outeniqua Basin (Agulhas Bank) 106
  Previous work 109
Systematic descriptions 109
Discussion 183
  Falkland Plateau 183
    Palaeoecology 184
    Biostratigraphy 192
  South-east Africa 194
    Zululand 194
      Palaeoecology 194
      Biostratigraphy 198
    Outeniqua Basin 200

Ann. S. Afr. Mus. **93**(3), 1984: 97–211, 42 figs, 14 tables.

PAGE
Regional considerations 200
Mid-Cretaceous faunal links between south-east Africa and the Falkland Plateau 204
Acknowledgements 207
References 207

INTRODUCTION

Mid-Cretaceous time spans the period in southern African geological history during which its south-eastern margin moved laterally past the Falkland Plateau as the African and South American continental blocks progressively separated in the early opening phase of the South Atlantic Ocean (e.g. Dingle & Scrutton 1974) (see Figs 1, 42 herein.) The commencement of continental drift (as defined by the creation of earliest oceanic crust between the separating continental units) probably dates from about 127 m.y. (Valanginian) (Larson & Ladd 1973), while its continuation resulted in the progressive enlargement of the

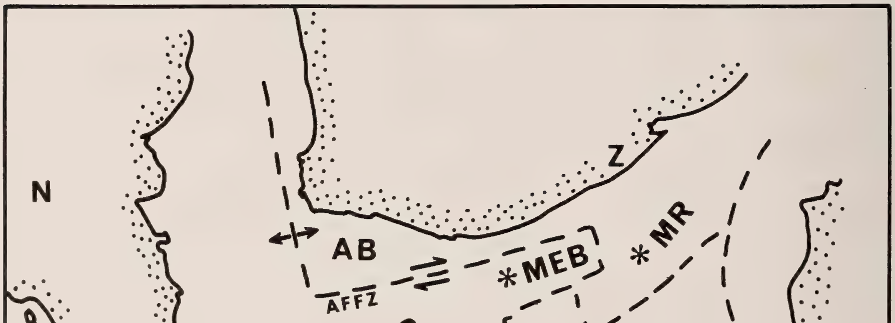

Fig. 1. Sketch of pre-drift reconstruction of part of south-western Gondwanaland. East Antarctica probably began to move away from West Gondwana (South America and Africa) in Jurassic times, but the Falkland Plateau remained in the position shown until latest Valanginian time. Amended from Dingle *et al.* (1983), which was based on Norton & Sclater (1979), Tucholke *et al.* (1981), De Wit (1977), and Elliot (1975). Dashed lines are lines of later continental breakup and arrows show directions of relative motion during continental separation. Stars shows positions of DSDP samples 249 (Mozambique Ridge) and 327 and 330 (Falkland Plateau). Abbreviations: N—Neuquen Basin; AB—Agulhas Bank (Outeniqua Basin); Z—Zululand–South Mozambique Basin; FP—Falkland Plateau; MEB—Maurice Ewing Bank; MR—Mozambique Ridge; WA—West Antarctica microplates; EA—East Antarctica; AFFZ—Agulhas–Falkland Fracture Zone.

south-eastern Atlantic Ocean and the southern Natal Valley. Because of the large spreading ridge offset created by the Agulhas–Falkland Fracture Zone (AFFZ in Fig. 1), the two continents remained physically joined along a progressively shortening zone until about 100 m.y. (late Albian–early Cenomanian). In a consideration of the Barremian to Cenomanian ostracod faunas of south-east Africa it is important, therefore, to include those of the same age from the Falkland Plateau because the Agulhas Bank, Falkland Plateau, and Zululand were close together in a slowly evolving palaeogeography, and their faunas can be expected to show similarities (Fig. 1).

Figure 1 shows a pre-drift reconstruction of the south-east Africa–Falkland Plateau area, and localities from which samples were available for study. Table 1 shows the distribution of the ostracods recovered during the study.

ZULULAND

The mid-Cretaceous (Barremian–Cenomanian) rocks of Zululand crop out as a narrow swathe along the eastern side of the Lebombo Mountains in northern Zululand, at the western edge of the coastal plain (Fig. 2). This is one of the areas from which Kennedy & Klinger (1975) collected during their revision of the Cretaceous ammonite faunas of south-east Africa, and the locality numbers used in Figure 2 are the same as theirs. Kennedy & Klinger (1975) divided the succession into two formations, which are separated by a hiatus across the Aptian–Albian boundary, with Albian I strata missing at outcrop.

The lower, Makatini Formation rests unconformably upon weathered Lebombo lavas, and the oldest marine sediments in this sequence have been dated as late Barremian. Unfortunately, none of the Makatini Formation older than Aptian III contained ostracods and, consequently, all our material comes from the upper two ammonite zones (Aptian III and IV), with exposures in two areas, Mkuze and Mlambongwenya. At the former, localities 152 and 150 occur in the Mantuma rest camp area of the Mkuze Game Park, to the south of the Mkuze River. Locality 150 (27°35,8′S 32°12,47′E) is a cliff section on the southern side of the Nhlohlela Pan, and exposes Aptian III–IV, while locality 152 (27°35,65′S 32°12,88′E) consists of hillslopes south of the road leading to Nhlohlela Pan from Denyer's Drift 500 m west of the camp area (Fig. 3). According to Kennedy & Klinger (1975), the latter exposes a section across the Makatini—Mzinene boundary (Aptian IV, Albian II–III), but only the lower part (Aptian IV) contains ostracods. At the Mlambongwenya Spruit section (locality 171, 27°10,98′S 32°11,13′E) good sections in the river cliff and hillslopes 250 m west-south-west of the store on the main road north from Jozini expose the succession across the Makatini–Mzinene boundary, and in this area ostracods occur in all three ammonite zones involved, Aptian IV, Albian II–III (Fig. 3). Kennedy & Klinger's (1975) work shows that the Albian–Cenomanian boundary is conformable, and that the top of the Mzinene Formation is unconformably overlain by the St. Lucia Formation throughout Zululand, so that the basal rocks of the

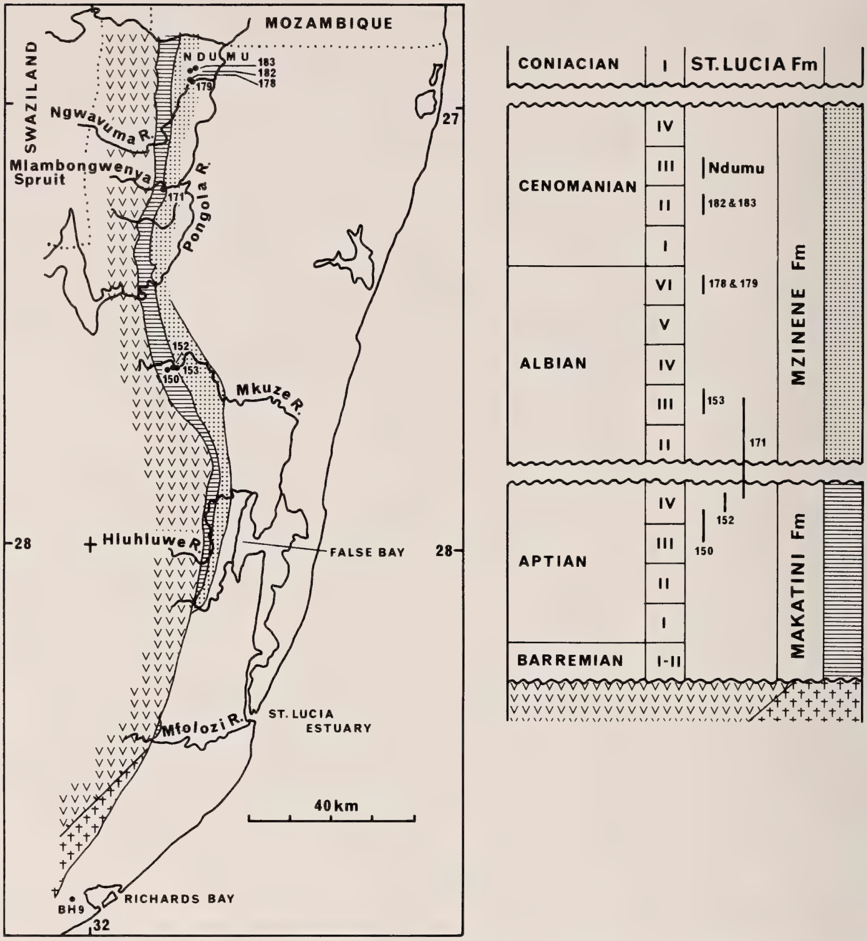

Fig. 2. Mid-Cretaceous strata of Zululand and sampling localities from which ostracods were recovered. Subdivision of stages is after Kennedy & Klinger (1975) and is based on ammonite faunas. Geological map is after Kennedy & Klinger (1975) with minor additions from Dingle *et al.* (1983). Pre-Barremian basement rocks are Mesozoic Lebombo volcanics and Pre-Cambrian metamorphics and granites. Locality numbers are those of Kennedy & Klinger (1975). Barremian I & II ammonite faunas are Upper Barremian in age. BH9 is the Richards Bay borehole, whose ostracod fauna has been described by Dingle (1980).

latter (Coniacian I hereabout) progressively overstep the latter (Cenomanian IV) with the whole of the Turonian missing at outcrop.

As mentioned above, we have ostracods from the basal Mzinene Formation (Albian II at Mlambongwenya Spruit), in addition to material from the next ammonite zone (Albian III) at locality 153 (27°35,60′S 32°13,16′E). This is another Mantuma rest camp exposure, which is in the banks of an excavated site for a reservoir at the camp just east of Dreyer's Drift. Ostracods were not recovered from samples that were taken from ammonite stages Albian IV–V, but material

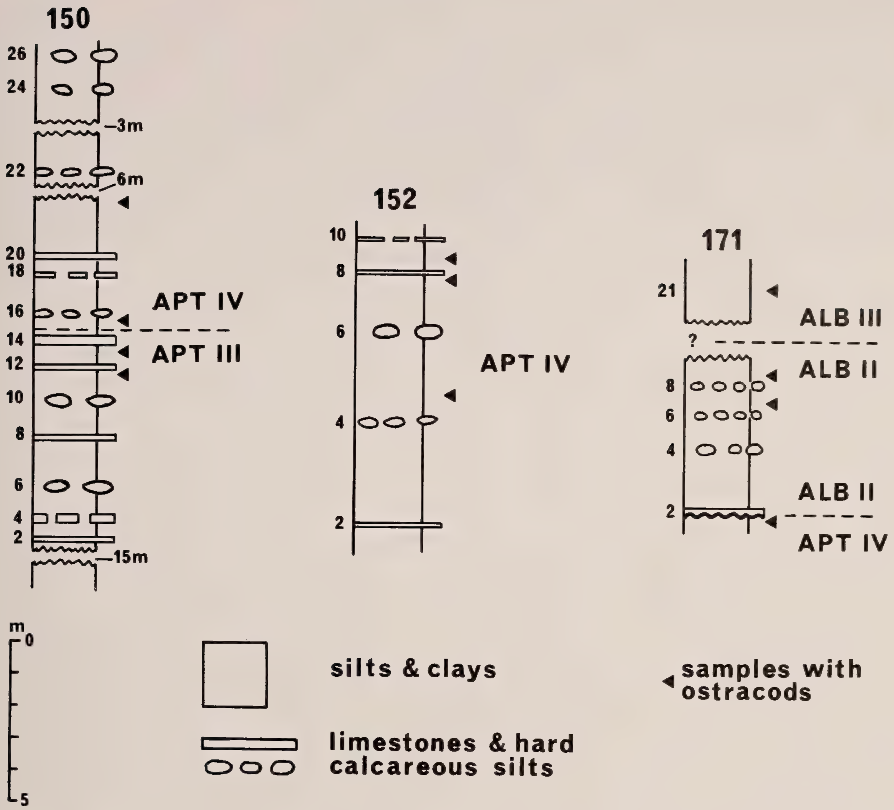

Fig. 3. Measured sections in the Makatini and Mzinene formations of Zululand. See Figure 2 for locations and the text for coordinates. After Kennedy & Klinger (1975), Klinger (pers. comm.), and personal field notes. Locality and bed numbers are those of Kennedy & Klinger (1975). Horizons with ostracod-bearing samples are shown with arrows. Other localities mentioned in the text do not show sections suitable for illustration: 153 is a small quarry exposing a few metres only of calcareous nodules in clays and silts; 178, 179, 182, and Ndumu are scattered outcrops in fields, watercourses and along tracks.

from two localities (178: 26°56,23′S 32°14,42′E, and 179: 26°56,46′S 32°14,92′E) provided fauna of Albian VI age. Both these are in shallow excavations in sisal fields in the vicinity of Msunduzi Pan, south-west of the Ndumu store in northernmost Zululand. Cenomanian I samples did not contain ostracods, but Cenomanian II faunas were recovered from localities 182 (26°55,63′S 32°15,22′E) and 183 (26°55,17′S 32°15,75′E). The former are poor exposures on the hillside south-east of Ndumu store, while the latter were taken in a small quarry in the hillside 300 m below Ndumu police station. The youngest mid-Cretaceous ostracod-bearing sample (Cenomanian III) was collected at the eastern end of Inyamathi Pan in the Ndumu Game Reserve (26°53,0′S 32°18,10′E, referred to as sample ‘Ndumu’ herein because it was not allocated a locality number by Kennedy & Klinger (1975)). To allow international correlation of the ostracod

TABLE 1
Distribution of mid-Cretaceous ostracods in Zululand, Agulhas Bank and Falkland Plateau

Sp. no.	Zululand ammonite stages DSDP biostratigraphy	Aptian			Albian						Cenomanian			
		I & II	III	IV	hiatus	II	III	IV	V	VI	I	II	III	IV
					early		middle		late		early			
13	*Majungaella ?hemigymnae*	—	—	*										
43	*Aitkenicythere?* sp. 327/18	—	—	—	—	—	—	*						
10	*Sondagella theloides*	—	—	—	—	—	*	—	*					
12	*Majungaella nematis*	—	—	*	—	—	*	—	—	—	—	*		
46	Indet. sp. 1		*											
6	*Bairdoppilata* sp.1			*										
24	*Procytherura* cf. *aerodynamica*			*										
47	Indet. sp. 2			*										
4	*Cytherelloidea makatiniensis*			*	—	—	*							
20	*Pirileberis mkuzensis*			*	—	—	*							
21	*Makatinella inflata*			*	—	—	*							
23	*Pongolacythere striata*			*	—	—	*							
19	*Pirileberis makatiniensis*			*	—	—	*							
29	*Pariceratina liebaui*			—	—	—	*	*						
2	*Cytherella* sp.			*	—	*	*	—	—	—	—	*	*	
8	*Paracypris* sp.			*	—	*	*	—	—	*	—	—	*	
22	*Makatinella tritumida*			*	—	*	*	—	—	—	—	*	*	
3	*Cytherelloidea agulhasensis*				*									
18	*Cythereis agulhasensis*				*									
11	*Majungaella* cf. *queenslandensis*				*	—	—	—	*					
32	*Eucytherura stellifera*					*								
44	*Aitkenicythere? striosulcata*					*	*							

15	*Arcuacythere tumida*	*	*		*	*	*			
30	*Pedicythere falklandensis*		*							
31	*Eucytherura rugosa*		*							
34	*Hemingwayella (Parahemingwayella) dalzieli*		*							
35	*H. (P.) reticulata*		*							
36	*Hemiparacytheridea ewingensis*		*							
37	*H. challengeri*		*							
39	*Asciocythere? dubia*		*							
48	Indet. sp. 330/1		*							
25	*Procytherura batei*		*		*					
33	*Hemingwayella (P.) barkeri*		*		*					
40	*Cytheropteron bispinosa*		*		*					
16	*Isocythereis sealensis*		*		*	*	*			
27	*Sphaeroleberis?* sp.			*				*		
26	*Procytherura* cf. *dinglei*				*					
41	*Cytheropteron* sp. 327/18				*					
49	Indet. sp. 327/16A				*					
50	Indet. sp. 327/18				*					
51	Indet. sp. 327/16B				*					
14	*Majungaella?* sp. 327/16				*					
38	*Collisarboris? stanleyensis*				*		*			
45	*Cytherura? oertlii*				*		*			
42	*Cytheropteron* sp.					*				
28	*Monoceratina?* sp.							*		
17	*Isocythereis? ndumuensis*							*	*	*
5	*Cytherelloidea ndumuensis*								*	

—*, known extension of range either outside south-east Africa–Falkland Plateau area, or older than mid-Cretaceous

TABLE 1

Distribution of mid-Cretaceous ostracods in Zululand, Agulhas Bank and Falkland Plateau

		Aptian						Albian												Cenomanian						
Sp.	Zululand ammonite stages	I & II		III		IV		hiatus		II		III		IV		V		VI		I		II		III		IV
no.	DSDP biostratigraphy							early				middle				late				early						
13	*Majungaella ?hemigymnae*	—	—	—	—	*																				
43	*Aitkenicythere?* sp. 327/18	—	—	—	—	—	—	—	—	—	—	—	*													
10	*Sondagella theloides*	—	—	—	—	—	—	—	—	—	—	*	—	—	*											
12	*Majungaella nematis*	—	—	—	—	*	—	—	—	—	—	*	—	—	—	—	—	—	—	—	—	*				
46	Indet. sp. 1			*																						
6	*Bairdoppilata* sp.1					*																				
24	*Procytherura* cf. *aerodynamica*					*																				
47	Indet. sp. 2					*																				
4	*Cytherelloidea makatiniensis*					*	—	—	—	—	—	*														
20	*Pirileberis mkuzensis*					*	—	—	—	—	—	*														
21	*Makatinella inflata*					*	—	—	—	—	—	*														
23	*Pongolacythere striata*					*	—	—	—	—	—	*														
19	*Pirileberis makatiniensis*					*	—	—	—	—	—	*														
29	*Pariceratina liebaui*					—	—	—	—	—	*	—	*													
2	*Cytherella* sp.					*	—	—	—	*	—	*	—	—	—	—	—	—	—	—	—	*	—	*		
8	*Paracypris* sp.					*	—	—	—	*	—	*	—	—	—	—	—	*	—	—	—	—	—	*		
22	*Makatinella tritumida*					*	—	—	—	*	—	*	—	—	—	—	—	—	—	—	—	*	—	*		
3	*Cytherelloidea agulhasensis*						*																			
18	*Cythereis agulhasensis*						*																			
11	*Majungaella* cf. *queenslandensis*						*	—	—	—	—	—	—	—	*											
32	*Eucytherura stellifera*								*																	
44	*Aitkenicythere? striosulcata*								*	—	*															
7	*Bairdoppilata* sp.2								*	—	*	—	*													
1	[illegible]									—		—	*	—	—	—	*									
9	*Robsoniella falklandensis*								*	—	*	—	*	—	—	—	*									
15	*Arculicythere tumida*								*	—	*	—	*	—	*	—	*									
30	*Pedicythere falklandensis*										*															
31	*Eucytherura rugosa*										*															
34	*Hemingwayella (Parahemingwayella) dalzieli*										*															
35	*H. (P.) reticulata*										*															
36	*Hemiparacytheridea ewingensis*										*															
37	*H. challengeri*										*															
39	*Asciocythere? dubia*										*															
48	Indet. sp. 330/1										*															
25	*Procytherura batei*										*	—	*													
33	*Hemingwayella (P.) barkeri*										*	—	*													
40	*Cytheropteron bispinosa*										*	—	*													
16	*Isocythereis sealensis*										*	—	*	—	*	—	*									
27	*Sphaeroleberis?* sp.											*	—	—	—	—	—	*								
26	*Procytherura* cf. *dinglei*												*													
41	*Cytheropteron* sp. 327/18												*													
49	Indet. sp. 327/16A												*													
50	Indet. sp. 327/18												*													
51	Indet. sp. 327/16B												*													
14	*Majungaella?* sp. 327/16												*													
38	*Collisarboris? stanleyensis*												*	—	—	—	*									
45	*Cytherura? oertlii*												*	—	—	—	*									
42	*Cytheropteron* sp.														*											
28	*Monoceratina?* sp.																	*								
17	*Isocythereis? ndumuensis*																	*	—	—	—	*	—	*		
5	*Cytherelloidea ndumuensis*																					*				

—*, known extension of range either outside south-east Africa–Falkland Plateau area, or older than mid-Cretaceous ranges presented herein, Table 2 includes details of the ammonite faunas of Kennedy & Klinger's (1975) zones.

Preservation of the Zululand mid-Cretaceous ostracoda is generally moderate to poor, with signs of local heavy decalcification. Many of the samples collected were barren. This contrasts strongly with the Campanian–Maastrichtian assemblages from Zululand, which are generally well preserved (Dingle 1981), and it suggests local deep weathering (i.e. subaerial exposure) during the Turonian hiatus.

Table 2

Ammonite zonation of Barremian to Cenomanian sediments in Zululand (after Kennedy & Klinger 1975).

CENOMANIAN IV: Sparsely fossiliferous. Fauna includes *Calycoceras* gr. *choffati, C. nitidum, C.* gr. *naviculare* and *Eucalycoceras*. Highest parts of the Cenomanian are missing.

CENOMANIAN III: *Turrilites acutus* is abundant throughout, while *Acanthoceras* spp. are abundant in the lower part and *Calycoceras* gr. *choffati* abundant in the upper part. Other forms include *Turrilites costatus, T. scheuchzerianus, Acanthoceras cornigerum, Forbesiceras largilliertianum, F. sculptum, Calycoceras gentoni paucinodatum*, and species of *Desmoceras, Hypophylloceras, Borissiakoceras, Anisoceras, Stomohamites, Sciponoceras, Scaphites, Puzosia*, and *Bhimaites*.

CENOMANIAN II: *Neostlingoceras rorayensis* is common, with the remainder of the fauna consisting of *Hypoturrilites carcitanensis, H. gravesianus, H. tuberculatus, H. nodiferus, Mariella* spp., *Sciponoceras roto, Scaphites*, sp. *Desmoceras latidorsatum, Tetragonites subtimotheanus, Forbesiceras largilliertianum, Sharpeiceras laticlavium, Mantelliceras* spp., and a number of desmoceratids.

CENOMANIAN I: *Sharpeiceras florencae, S. falloti*, and *Mariella oehlerti* are abundant. Other forms include *Desmoceras latidorsatum, Sciponoceras roto, Scaphites* cf. *simplex*, and species of *Mariella, Ostlingoceras, Hypoturrilites*, and *Mantelliceras*.
The local base is drawn at the incoming of abundant representatives of *Sharpeiceras* and *Mariella oehlerti*.

ALBIAN VI: Characterized by the appearance of species of *Durnovarites* and *Stoliczkia*. Species of *Idiohamites, Hamites*, and *Anisoceras* are abundant, while species of *Lechites, Mariella, Hypengonoceras*, and *Tetragonites* and puzosiids are scarcer.

ALBIAN V: Characterized by the abundance of mortoniceratids. Genera present include *Hysteroceras, Oxytropidoceras, Tarfayites, Dipoloceras, Diplasioceras, Mortoniceras, Deiradoceras, Erioliceras, Arestoceras, Cainoceras, Puzosia, Bhimaites, Desmoceras, Hypophylloceras, Anagaudryceras, Gaudryceras, Tetragonites, Hamites, Anisoceras, Labeceras, Myloceras, Jouberticeras*, and *Protetragonites*.

ALBIAN IV: Species of *Oxytropidoceras, Manuaniceras* and *Androiavites* are common. Other genera present include *Pseudhelicoceras, Mojsisovicsia, Hypophylloceras velledae, Jouberticeras*, and *Argonauticeras*, and desmoceratids.

ALBIAN III: *Douvilleiceras* sp., *Anagaudryceras sacya, Eubrancoceras* aff. *aegoceratoides* and *Oxytropidoceras* sp. are abundant; representatives of *Carinophylloceras* are common and *Lyelliceras* frequent. Other forms include *Umsinenoceras, Hypophylloceras, 'Beaudanticeras', 'Cleoniceras', 'Sonneratia', Rossalites, Ammonoceratites, Alopeceras, Argonauticeras* and *Pictetia*.

ALBIAN II: *Douvilleiceras* spp. including *D. orbignyi* and *D. mammillatum*, are abundant. Other forms are scarce, but include *Ammonoceratites, Pictetia* and democeratids and lytoceratids.

ALBIAN I: Absent.
Local base drawn at appearance of representatives of *Douvilleiceras*.

APTIAN IV: Giant, fine-ribbed forms of *Tropaeum* are abundant, and *Lytoceras* is common. Other forms include *Tonohamites, Acanthoplites, Diadochoceras nodosocostatum, Australiceras, Sinzovia, Toxoceratoides, Helicancyloceras*, and *Nonyaniceras*.

APTIAN III: Characterized by an abundance of *Acanthoplites, ?Diadochoceras, Valdedorsella, Phylloceras, Ancyloceras, Protanisoceras, Tonohamites*, and *Lytoceras*. Other forms include *Tropaeum, Australiceras, Toxoceratoides, Helicancyloceras*, and *Nonyaniceras*.

APTIAN II: *Cheloniceras* s.s. becomes frequent, together with *Valdedorsella* or *Pseudohaploceras, Ancyloceras, Tropaeum* and *Australiceras*. Other forms include *Lytoceras, Adouliceras*, and *Toxoceratoides*. A non-sequence may separate Aptian II and I.

APTIAN I: *?Procheloniceras* is abundant. Other forms include *Tropaeum, Ancyloceras, Theganeceras, Lytoceras, Adouliceras*, and *Australiceras*.
Local base drawn at appearance of cheloniceratids.

BARREMIAN II: *Colchidites* spp. occur in very large numbers. Other forms include *Sanmartinoceras, Phylloceras, Lytoceras* and *Ancyloceras*.

BARREMIAN I: Characterized by an abundance of crioceratitids including hemihoplitids and aconeceratids, and species of *'Emericiceras', 'Acrioceras', Heteroceras*, and *?Sanmartinoceras*, and *Phylloceras serum* and *Eulytoceras phestum*. Occasional species of *Colchidites, Lytoceras*, and *Ancyloceras* also occur.
Local base drawn at appearance of ammonite faunas, and the presence of *Colchidites* indicates an Upper Barremian age.

FALKLAND PLATEAU

Leg 36 of the Deep Sea Drilling Project (Barker *et al.* 1977) drilled three holes on the eastern end of the Falkland Plateau. Cores through mid-Cretaceous rocks were collected at sites 327 and 330 from which nine and three ostracod-bearing samples, respectively, were obtained by the writer from the sample repository at the Lamont–Doherty Geological Observatory (Fig. 4). The stratigraphy of these sites has been discussed in detail by Barker *et al.* (1977) (Table 3), and reviewed in the context of their palaeogeographical position adjacent to south-east Africa by Dingle *et al.* (1983).

At both sites, which lie on the western edge of the Maurice Ewing Bank, early–middle Albian nannofossil-rich clays overlie dark, anoxic clays and claystones of Aptian age. The latter do not contain calcareous benthic microfossils, and are considered to have been deposited in stagnant and/or reducing conditions that had persisted over the area since Upper Jurassic times. Sediments younger than Albian were not encountered at site 330, but at 327 the uppermost part of the Cenomanian sequence (core 14) is in a zeolitic clay facies, and this passes, presumably via a non-sequence into Santonian zeolitic claystones. A large hiatus, approximately corresponding to the Upper Cenomanian to Coniacian break in Zululand (Fig. 2) can, therefore, also be inferred on the Falkland Plateau, although by the beginning of this event (Upper Cenomanian), the Falkland Plateau had already separated from the southern tip of the Agulhas Bank (see Fig. 42b).

Ostracods occur at all the sampled levels, with the exception of core 14 (Cenomanian), so that material of early, middle, and late Albian ages was available for study from twelve samples. For simplicity in description, the nine samples from site 327 have been given informal numbers 1–9 (see Table 6). Because the size of each sample was small (*c.* 20 cc), the ostracod faunas were relatively small and vary from 13 to 119 valves. A total of 543 valves was recovered. Many of these are very small specimens, and one of the characteristics of the Falkland Plateau mid-Cretaceous assemblages is the large percentage of micro-ostracods (<450μ length). Preservation varies from good to moderate.

OUTENIQUA BASIN (AGULHAS BANK)

Two samples of mid-Cretaceous age, dredged from the sea-floor south of Plettenberg Bay during geological mapping on the Agulhas Bank, have previously been investigated by Dingle (1971) (see Fig. 42b for locations). In the present study, their small, but relatively well-preserved, ostracod assemblages are re-illustrated with SEM photographs, and the taxonomy revised. These samples turn out to be particularly important because they were deposited adjacent to the Falkland Plateau, and contain a fauna that has elements common to the Falkland Plateau, Zululand, and western Australia.

Sample TBD 1113 (34°15,0′S 23°36,6′E, 95 m water depth). A dark-grey clay containing abundant small unidentifiable shell fragments, glauconite, and comminuted carbonaceous material, and small irregular calcareous nodules. In addition to ostracods, several microfossil taxa have been recorded from this sample, and Luterbacher (reported in Dingle 1971) correlates the benthic foraminiferal assemblage with assemblage zone F (Valanginian to Aptian) of Espitalie & Sigal (1963) from Madagascar (Table 4), and notes that *Epistomina (Brotzenia)* sp. ex gr. *E. (B.) spinulifera* has a range Barremian to Albian. On the basis of calcareous nannofossils, Siesser (1982) suggests a Middle Albian–Maastrichtian age. Overlap of the ranges of these various taxa indicates a Middle–Upper Albian age for sample 1113. Because of the uncertainties of both age and lithostratigraphic correspondence of the Upper Sundays River and lower Alphard formations (e.g. see Dingle *et al.* 1983), assignment of this sample to a lithostratigraphic unit has to be provisional, but it probably belongs to the Alphard Formation. Sample 1113 contained a relatively rich and well-preserved ostracod fauna (5 spp., 91 valves).

Sample TBD 1266 (34°14,1′S 23°23,0′E, 102 m water depth). A stiff dark-grey clay containing abundant unidentifiable shell fragments, and glauconite grains.

Luterbacher (in Dingle 1971) recognized only two benthic foraminifera in this sample, but considered it to be of a similar age to sample 1113 (Table 4). Siesser (1982) dated the sample as Upper Aptian–Lower Santonian on the basis

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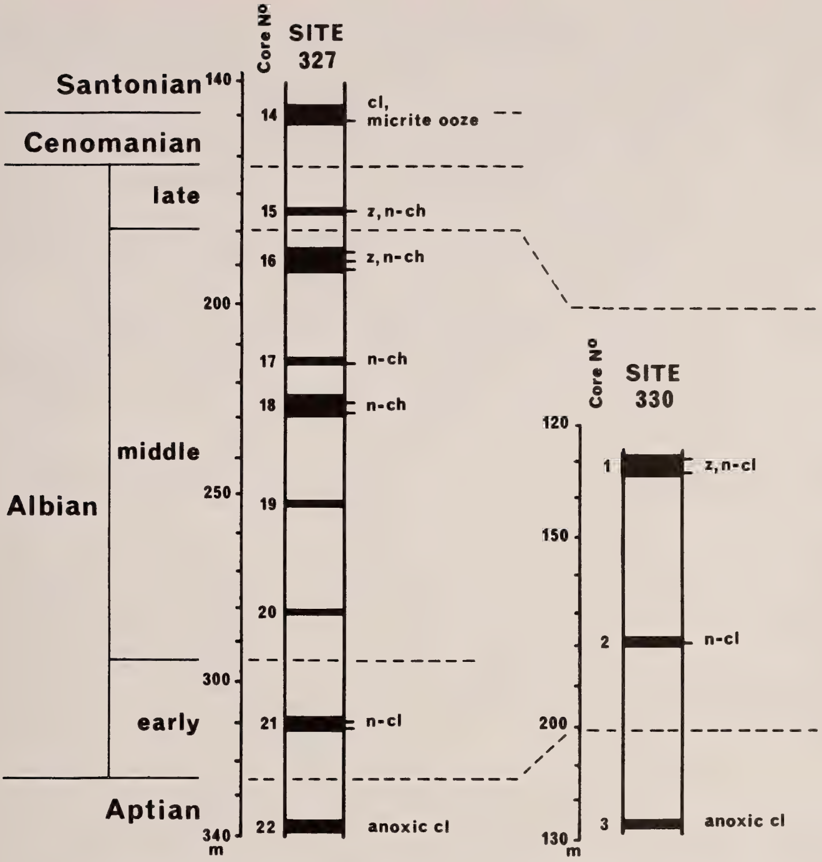
Fig. 4. Stratigraphy and location of DSDP boreholes 327 and 330 on the Falkland Plateau (after Barker *et al.* 1977). Isobaths are in km, depths of the boreholes in m below the sea-floor. Cored sections are black units, and ticks on right side of each column show sediment sample positions, all of which, except core 14, contained ostracods. Lithological notation: cl—clay, z—zeolite-rich, n—nanno, ch—chalk.


Core No
SITE 327
Santonian
Cenomanian
late
middle
Albian
early
Aptian
140
200
250
300
340 m
14
15
16
17
18
19
20
21
22
cl, micrite ooze
z, n-ch
z, n-ch
n-ch
n-ch
n-cl
anoxic cl
Core No
SITE 330
120
150
200
130 m
1
2
3
z, n-cl
n-cl
anoxic cl

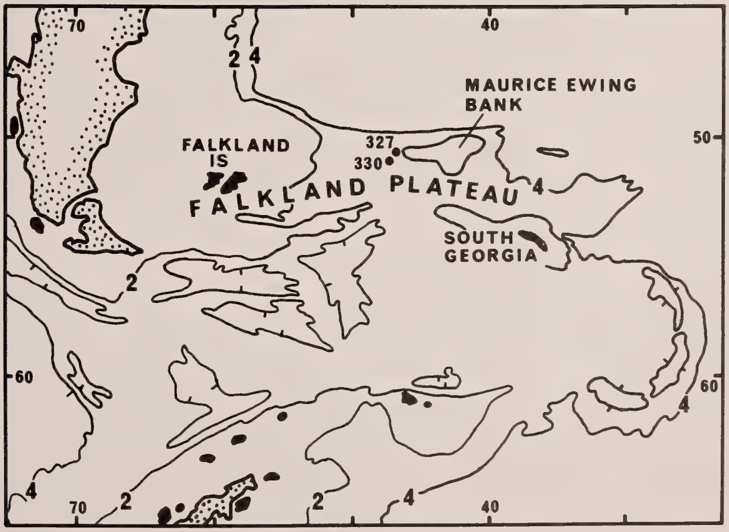

70
40
50
60
70
40
60
2
4
MAURICE EWING BANK
FALKLAND IS
327
330
FALKLAND PLATEAU
SOUTH GEORGIA
2
4
2
4
2
4

TABLE 3

Age determinants in DSDP boreholes 327 and 330 (after Barker *et al.* 1977) (see Fig. 4 for core logs).

SITE 327A	
Core 14	Sections 1–5 contain the coccolith *Marthasterites furcatus* and/or foraminifera which suggest a Santonian age. Section 6 contains *Rotalipora reicheli* and coccoliths which indicate a Cenomanian age.
Core 15	Specimens of *Aucellina*, and coccoliths assigned to *Eiffellithus turriseiffeli* Zone indicate a late Albian age.
Cores 16 to 21	Assigned to *Prediscosphaera cretacea* Zone, which is considered early to middle Albian. Planktonic foraminifera indicate a middle Albian age for cores 16–20 (*Globigerinelloides bentonensis, G. caseyi, Hedbergella delrioensis, H. amabilis, H. portsdownensis*, and *H. planispira*), and early to possibly middle Albian for core 21 (*Hedbergella sigali, H. planispira, H. delrioensis*, and *Globigerinelloides gyroidinaefomis*).
Core 22	Contains the coccolith *Lithostrinus floralis* and is assigned to the *Parhabdolithus angustus* Zone, which is probably late Aptian to early Albian age. Palynomorphs indicate an Aptian age.
SITE 330	
Cores 1 to 2	Contain coccoliths referable to the early–middle Albian *Prediscosphaera cretacea* Zone.
Core 3	Dated Aptian on the basis of coccoliths, foraminifera, and pollen. It probably belongs to the coccolith *Chiastozygus litterarius* Zone.

TABLE 4

Microfossils (other than ostracods) recorded from Agulhas Bank samples 1113 and 1266 (Dingle 1971; Siesser 1982).

FORAMINIFERA	1113	1266
Epistomina (Brotzenia) alveata Espitalie & Sigal	x	x
E. (B.) sp. sp. ex gr. *E. (B.) spinulifera* (Reuss)	x	
E. (B.) sp. aff. *E. (B.) caracolla* (Roemer)	x	x
Lenticulina sp.	x	
Citharinella sp.	x	
Vaginulina (Citharina) sp. aff. *V. (C.) aptiensis* Eichenberg, (cf. sp. 2378C of Espitalie & Sigal 1963)	x	
CALCAREOUS NANOFOSSILS		
Watznaueria barnesae (Black)	x	c
Eiffellithus turriseiffeli (Deflandre)	x	
Lithraphidites carniolensis Deflandre		f
Lithastrinus floralis Stradner		f
Manivitella pemmatoidea (Deflandre)		r
Prediscosphaera spinosa (Bramlette & Martini)		r
Lapideacassis sp.		r
Thoracocphara sp.		r
Zygodiscus sp.		r

x = present, r = rare, c = common, f = frequent of the range of the coccolith *Lithastrinus floralis*. An overlap of the suggested foraminifera and coccolith ranges indicates an Upper Aptian–Albian age, with the sample probably belonging to the Alphard Formation.

Only three ostracod specimens were obtained from sample 1266.

PREVIOUS WORK

Apart from the original descriptions of samples 1113 and 1266 by Dingle (1971), no previous work has been published on mid-Cretaceous (Aptian to Cenomanian) ostracods from southern Africa, although preliminary determinations on the Zululand faunas made from the present work were incorporated in a general survey of Cretaceous ostracod faunas by Dingle (1982). Work on faunas from the originally adjacent areas in Gondwanaland have proved valuable for comparative purposes, and in the discussion section the significance of the close relationships recognized across the whole southern Gondwanaland region will be discussed. Relevant works in this category are: Aptian to Cenomanian from Tanzania (Bate in Bate & Bayliss 1969); Albian from DSDP sites off north-western Australia (Oertli 1974); Albian from the Artesian Basin of Queensland (Krömmelbein 1975); Upper Jurassic–Lower Cretaceous from the Rann of Kutch, India (Guha 1976); Neocomian from the Mozambique Ridge DSDP site 249 (Sigal 1974). In addition, because some of the taxa encountered in the present study range downward into the Upper Jurassic, the studies of Grekoff (1963) on the Middle Jurassic to Valanginian of Madagascar; Dingle (1969); Brenner & Oertli (1976); and McLachlan *et al.* 1976*b* on the ?Portlandian to Hauterivian of the Algoa and Outeniqua basins; and Musacchio (1978, 1979) on the Callovian and Hauterivian of Argentina are also relevant.

A total of 35 fossiliferous samples was available for study, from which 51 species of ostracod were identified (Tables 1, 5). Microfossils were extracted by washing and sieving, and were photographed with a Cambridge S180 Stereoscan at the University of Cape Town, and with a JEOL JSM T200 in the Micropalaeontology Research Unit of University College, London. Specimens were mounted on double-sided Sellotape, and were coated with a gold–palladium mixture. Type specimens and illustrated material were deposited in the South African Museum, Cape Town.

SYSTEMATIC DESCRIPTIONS

The classification used here is based on the Ostracod *Treatise* (Moore 1961), with various additions necessitated by recent work. Abbreviations: RV = right valve, LV = left valve, MPC = marginal pore canal, SCT = subcentral tubercle, TE = terminal element, ATE = anterior terminal element, PTE = posterior terminal element, ME = median element, AM = anterior margin, PM = posterior margin, DM = dorsal margin, VM = ventral margin, NPC = normal pore canal, RPC = radial pore canal, MA = marginal area, and CA = cardinal angle.

Subclass OSTRACODA Latreille, 1806

Order PODOCOPIDA Müller, 1894

Suborder PLATYCOPINA Sars, 1866

Family **Cytherellidae** Sars, 1866

This family is represented by two genera and five species, *Cytherella* (two species) and *Cytherelloidea* (three species), and occurs in all three areas under investigation. Distribution is, however, uneven, with *Cytherelloidea* being confined to the Agulhas Bank and Zululand, and *Cytherella* being relatively more abundant and consistent on the Falkland Plateau. In terms of the CCBC associations (see *Discussion* section), the Cytherellidae are consistently the minor element in the Falkland Plateau assemblages in DSDP 327.

Genus *Cytherella* Jones, 1849

Cytherella is represented by two species, which are restricted to Zululand (*Cytherella* sp.) and the Falkland Plateau (*C. bensoni*). In their respective areas, these are amongst the most abundant and consistently present members of the ostracod populations, although they are never the most important single species.

Cytherella bensoni sp. nov.

Figs 5A–B, 6

Derivation of name

In recognition of the work of Dr R. H. Benson (US National Museum, Washington) on South Atlantic Ostracoda.

Holotype

SAM–PC6017, RV, DSDP 36/327, core 18–6/106–110 cm, middle Albian.

Paratype

SAM–PC6018, LV, DSDP 36/327, core 18–6/106–110 cm, middle Albian.

Diagnosis

Small, fragile species with compressed anterior half, and faint ridges and reticulations in posterior half.

Description

External features. Small, rather fragile shell, subquadrate in lateral outline, with broadly rounded AM with narrow border, narrow truncated PM. DM straight, VM slightly concave. Highest part of valve at about third length. Anterior part of valve compressed, posterior part somewhat swollen, with weakly developed longitudinal ridges and small areas of incipient reticulation that are difficult to see in reflected light. There is a median sulcus with MS impressions.

Interior features. Typical for genus, MS clearly seen as a rosette (Fig. 6).

TABLE 5

Geographical distribution of mid-Cretaceous (Aptian–Cenomanian) Ostracoda from south-east Africa and adjacent areas. (Pre-mid-Cretaceous occurrences are starred.)

Sp. no.		Arg.	F.Plat.	A.B.	Zulul.	M.R.	Mad.	NW Aus.
1	*Cytherella bensoni*		x					
2	*C.* sp.				x			
3	*Cytherelloidea agulhasensis*			x				
4	*C. makatiniensis*				x			
5	*C. ndumuensis*				x			
6	*Bairdoppilata* sp. 1				x			
7	*B.* sp. 2		x					
8	*Paracypris* sp.				x			
9	*Robsoniella falklandensis*		x					x
10	*Sondagella theloides*	x*		x	x	x*		
11	*Majungaella* cf. *queenslandensis*			x				
12	*M. nematis*	x*		x*	x	x*	x*	
13	*M? hemigymne*				x			
14	*M?* sp. 327/16		x					
15	*Arculicythere tumida*		x	x				x
16	*Isocythereis sealensis*		x	x				
17	*I? ndumuensis*				x			
18	*Cythereis agulhasensis*			x				
19	*Pirileberis makatiniensis*				x			
20	*P. mkuzensis*				x			
21	*Makatinella inflata*				x			
22	*M. tritumida*				x			
23	*Pongolacythere striata*				x			
24	*Procytherura* cf. *aerodynamica*				x			
25	*P. batei*		x					
26	*P.* cf. *dinglei*		x					
27	*Sphaerolebris?* sp. A				x			
28	*Monoceratina?* sp.				x			
29	*Pariceratina liebaui*		x					
30	*Pedicythere falklandensis*		x					
31	*Eucytherura rugosa*		x					
32	*E. stellifera*		x					
33	*Hemingwayella (Parahemingwayella) barkeri*		x					
34	*H. (P.) dalzieli*		x					
35	*H. (P.) reticulata*		x					
36	*Hemiparacytheridea ewingensis*		x					
37	*H. challengeri*		x					
38	*Collisarboris? stanleyensis*		x					
39	*Asciocythere? dubia*		x					
40	*Cytheropteron bispinosa*		x					
41	*C.* sp.327/18		x					
42	*C?* sp.			x				
43	*Aitkenicythere?* sp. 327/18		x					x
44	*A? striosulcata*		x					
45	*Cytherura? oertlii*		x					x
46	Indet. sp. 1				x			
47	Indet. sp. 2				x			
48	Indet. sp. 330/1		x					
49	Indet. sp. 327/16A		x					
50	Indet. sp. 327/18		x					
51	Indet. 327/16B		x					
	totals 51 spp., 26 genera	2	28	8	19	2	1	4

Arg. = Argentina; F.Plat. = Falkland Plateau; A.B. = Agulhas Bank; Zulul. = Zululand; M.R. = Mozambique Ridge; Mad. = Madagascar; NW Aus. = north-western Australia

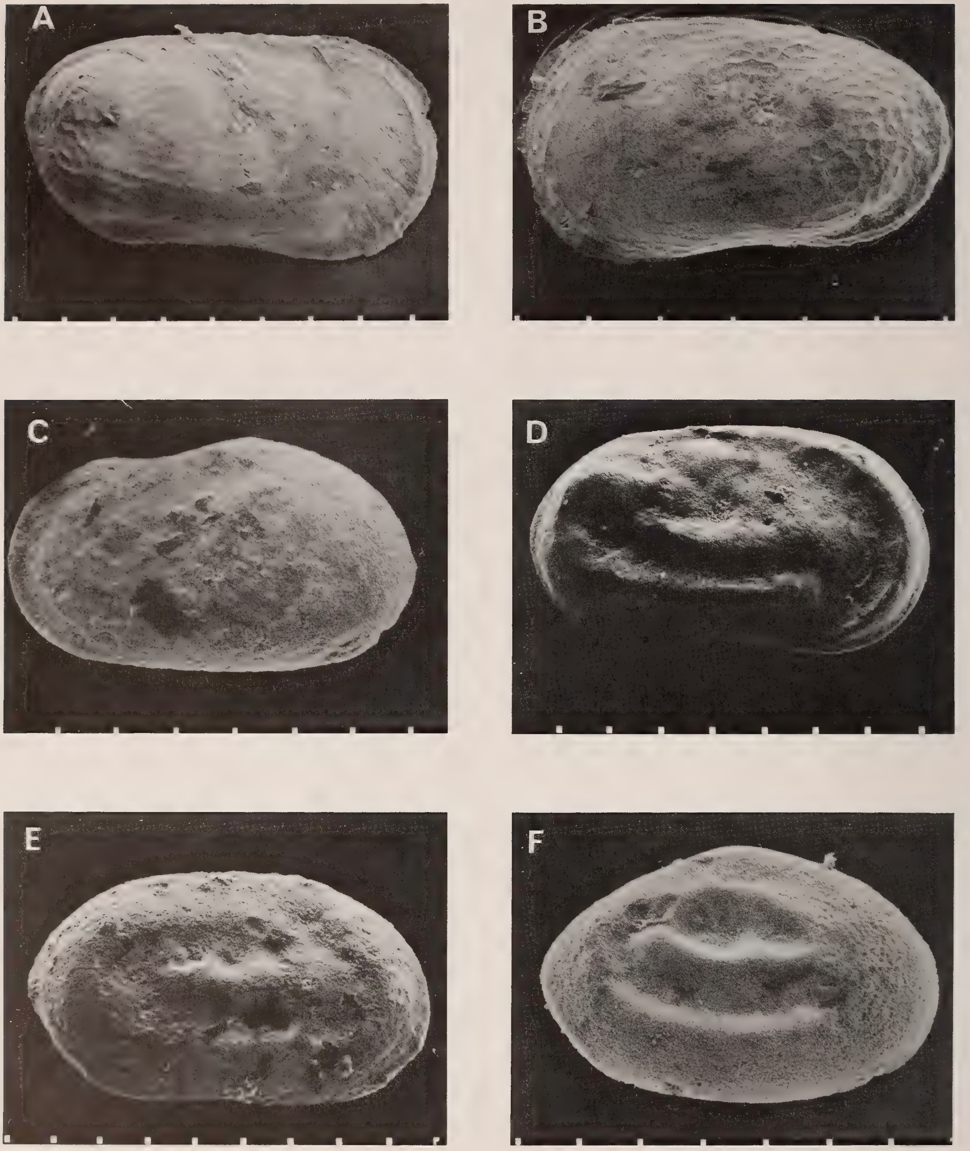


Fig. 5. A–B. *Cytherella bensoni* sp. nov., DSDP 327, core 18–6/106–110 cm, middle Albian. A. Holotype, SAM–PC6017, RV. B. SAM–PC6018, LV. C. *Cytherella* sp. SAM–PC6019, LV, locality 152–5, Mkuze, Zululand, Aptian IV. D. *Cytherelloidea agulhasensis* Dingle, 1971, holotype, SAM–PC6020, RV, TBD 1266, Agulhas Bank, Upper Aptian–Albian. E. *Cytherelloidea makatiniensis* sp. nov., holotype, SAM–PC6021, RV, locality 171–21, Mlambongwenya Spruit, Zululand, Albian III. F. *Cytherelloidea ndumuensis* sp. nov., holotype, SAM–PC6022, RV, locality 182, Ndumu store, Zululand, Cenomanian II.
Scale bars = 100 μ.

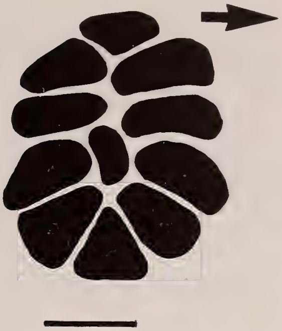


Fig. 6. Muscle scars, *Cytherella bensoni* sp. nov., holotype, SAM–PC6017 DSDP 327, core 18–6/106–110 cm, middle Albian. Impressions seen in external view, RV.
Scale bar = 30 μ.

Remarks

The slightly swollen posterior end with incipient ridges may suggest placement within *Cytherelloidea*, but on balance the overall shape and weakness of ornamentation are considered consistent with *Cytherella*.

Dimensions (mm)

	length	height
6017	0,83	0,46
6018	0,60	0,34

Age and distribution

C. bensoni occurs in most of the samples from DSDP sites 327 and 330 on the Falkland Plateau, and ranges over the entire section covered by the core material, i.e. early to middle Albian in 330, and early to late Albian in 327. It is a relatively abundant species (1–15%, average 7% in 330, and 5–23%, average 14% in 327).

Cytherella sp.

Fig. 5C

Remarks

Poorly preserved specimens of an indeterminate species of *Cytherella*, which has a rounded, inflated posterior area and a compressed anterior area with an incipient AM rim. The specimen illustrated in Figure 5C has a damaged DM, but is otherwise one of the best specimens available.

Age and distribution

Known from the Aptian IV to Cenomanian III interval in Zululand, where it occurs generally in moderate numbers (4–20% total ostracod population).

Genus *Cytherelloidea* Alexander, 1929

This genus is represented by three species that are restricted to the southern African outcrops: *agulhasensis* (Agulhas Bank), and *makatiniensis* and *ndumuensis* (Zululand). Only *C. makatiniensis* occurs in more than one ammonite zone (Aptian IV and Albian III), and none of the species has been recovered in large numbers.

Cytherelloidea agulhasensis Dingle, 1971

Figs 5D, 7C

Cytherelloidea agulhasensis Dingle, 1971: 397–398, fig. 2.

Remarks

No further specimens of this species have been recorded from either Zululand or the Falkland Plateau. SEM photographs show that the rib pattern of *C. agulhasensis* is similar to those of *C. mfoloziensis* Dingle, 1981, and *C. umzambaensis* Dingle, 1969, which range Campanian IV to Maastrichtian II in Zululand, and Santonian to Campanian IV in Transkei–Zululand, respectively.

All three have prominent antero- and posteromarginal, and short longitudinal ventrolateral ribs, but differ in their median and dorsolateral areas, where *C. agulhasensis* has irregular-shaped elevations in contrast to the ribs of the other two species (Fig. 7).

Holotype originally designated MG-5-1-1 (Dingle 1971), now transferred to the South African Museum under designation SAM–PC6020.

Age and distribution

Known only from sample TBD 1266 on the Agulhas Bank (Upper Aptian–Albian, Alphard Formation).

Cytherelloidea makatiniensis sp. nov.

Fig. 5E

Derivation of name

Locality of type specimen, Makatini Flats, northern Zululand.

Holotype

SAM–PC6021, RV, locality 171–21, Mzinene Formation, vicinity of store on Mlambongwenya Spruit, Zululand, Albian III.

Diagnosis

Rib pattern consists of an outer spiral and a short central rib.

Description

External features. AM broadly rounded, DM and VM nearly straight, PM rounded but somewhat truncated ventrally. A broad ridge can be traced from an anterodorsal position round the anterior, ventral, posterior, and dorsal regions in a flattened spiral, ending at about third length. It encloses a short median rib which has two dorsal cusps and a slight anterior swelling. Valve surface otherwise smooth.

Internal features. None seen.

Remarks

The rib pattern of *C. makatiniensis* is reminiscent of *C. mairae* Ramsay from the Campanian of Tanzania (Ramsay 1968), but differs in lacking both a well-defined connection between the middle rib and the outer spiral, and a hook at the posterior end of the middle rib.

Dimensions (mm)

	length	height
6021	0,82	0,49

Age and distribution

C. makatiniensis is known to range Aptian IV to Albian III (Makatini to Mzinene formations) in northern Zululand.

Cytherelloidea ndumuensis sp. nov.

Fig. 5F

Derivation of name

Locality of type specimen, Ndumu Game Reserve, northern Zululand.

Holotype

SAM–PC6022, RV, locality 182, Mzinene Formation, vicinity of Ndumu store, Cenomanian II.

Diagnosis

Species with strongly arched dorsal margin and three short longitudinal ribs.

Description

External features. Asymmetrically elliptical in outline, with evenly curved AM, somewhat acuminate PM, broadly rounded VM and strongly arched DM. The central area of the lateral surface has three short longitudinal ribs, which

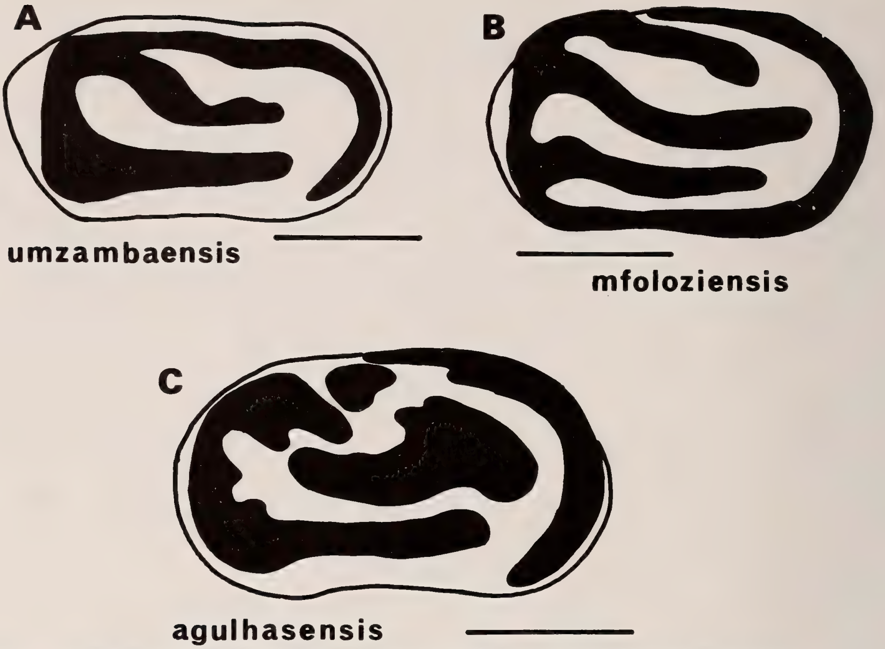


Fig. 7. Sketches of *Cytherelloidea* species, right valves, with positive features shaded. A. *C. umzambaensis* Dingle, 1969, Richards Bay borehole, Zululand, Santonian III (from Dingle 1980, fig. 3a). B. *C. mfoloziensis* Dingle, 1981, SAM–K5665, Mfolozi River, Zululand, Maastrichtian II. C. *C. agulhasensis* Dingle, 1971, SAM–PC6020, Agulhas Bank, Upper Aptian–Albian.
Scale bars = 300 μ.

progressively increase in length ventrally: the dorsal rib is very short and slightly convex dorsally, the middle rib is concave dorsally with a small cusp just in front of the valve mid-length and has a small posterior swelling, and the ventral rib is concave dorsally and curves upward posteriorly to partially enclose the two other ribs. The rest of the valve surface is smooth.

Internal features. None seen.

Remarks

C. ndumuensis has a rather unusual outline and distinctive rib pattern, which sets it aside from other species of the genus in southern Africa.

Dimensions (mm)

	length	height
6022	0,63	0,41

Age and distribution

Known only from the Cenomanian II of northern Zululand.

Suborder PODOCOPINA Sars, 1866

Superfamily BAIRDIACEA Sars, 1888

There is a marked constrast in the importance of this superfamily between Zululand and the Falkland Plateau: in the former it is of minor importance, whereas in the latter it is the dominant element (mainly with *Robsoniella*, consistently occurring at 50% total ostracod population in borehole 327).

Family **Bairdiidae** Sars, 1888

Genus *Bairdoppilata* Coryell, Sample & Jennings, 1935

The genus was recorded from two samples only in the Zululand mid-Cretaceous but, as may be expected, is more abundant in the deeper-water environments of the Falkland Plateau. Despite the poor quality of the comparative material from Zululand, we recognize the species from the two areas as distinct.

Bairdoppilata sp. 1

Fig. 8A

Remarks

Four poorly preserved valves whose closest known comparatives are the late Campanian–early Maastrichtian specimens of *B. andersoni* from the Lower Needs Camp Quarry east of Algoa Bay (Dingle 1981). *Bairdoppilata* sp. 1 differs from the Upper Cretaceous material in having a more broadly rounded AM outline.

Age and distribution

Known only from two Aptian IV horizons in Zululand, locality 152 (Mkuze) and locality 171 (Mlambongwenya Spruit).

Bairdoppilata sp. 2

Fig. 8B

Remarks

Species with an asymmetrically rounded AM and bluntly pointed PM, which distinguishes it from *Bairdoppilata* sp. 1 from Zululand (compare Fig. 8A–B).

Age and distribution

Ranges early to middle Albian at sites 327 (cores 21–3 to 16–6) and 330 (core 1–1) where it occurs in small to moderate numbers (2–22%) of total ostracod population. It is always less abundant than *Robsoniella falklandensis*. Samples with *Bairdoppilata* sp. 2 all cluster in the central portion of the field for site 327 populations on the CCBC diagram (Fig. 38). The significance of this is not known, but may identify median water depth assemblages at this site.

Genus *Robsoniella* Kusnetsova, 1956

In the original description (in Mandelstam *et al.* 1956) and in the *Treatise* (Moore 1961), *Robsoniella* was placed in the family Healdiidae. This seems inconsistent, and the genus is here placed in the family Bairdiidae on the grounds of MA structure and overall shape. *R. falklandensis* occurs on the Falkland Plateau, where it is the dominant taxon both in abundance and distribution, and off western Australia where it is again locally abundant.

Robsoniella falklandensis sp. nov.

Fig. 8C–F

?Indet sp. A, Oertli, 1974; plate 6 (figs 1–11).

Derivation of name

Locality of type specimens on the Falkland Plateau.

Holotype

SAM–PC6025, RV, DSDP 36/327, core 21–4/130–134 cm, early Albian.

Paratypes

SAM–PC6026, RV, DSDP 36/327, core 21–4/130–134 cm, early Albian.
SAM–PC6027, LV, as above.
SAM–PC6028, LV, as above.

Diagnosis

Ovate species with markedly different RV and LV outlines. Hinge weak with a prominent sloping surface over the RV ME.

Description

External features. LV and RV differ considerably in shape, but both are ovate. RV has asymmetric AM with long sloping anterodorsal section, PM more broadly rounded, but also asymmetric. Greatest length below mid-height. DM arched, VM almost straight with median concavity. Greatest height in posterior half. LV is less elongate, AM and PM broadly rounded and almost the same shape, DM arched, VM weakly convex. Both valves smooth overall.

Internal features. MA moderately wide, small vestibule anteriorly, but despite good material, no RPC seen. If present, they must be extremely fine. MS not identified despite good material. Hinge in RV consists of a narrow ME groove and narrow, elongate TE; in LV it consists of a narrow, finely crenulate ME bar and elongate slit-like TE.

Remarks

In outline *R. falklandensis* closely resembles *Bythocypris richardsbayensis* Dingle, 1980, from the Upper Cretaceous of Zululand, but the two differ in hinge structure, MA, MS pattern (very weak in the former, large and prominent

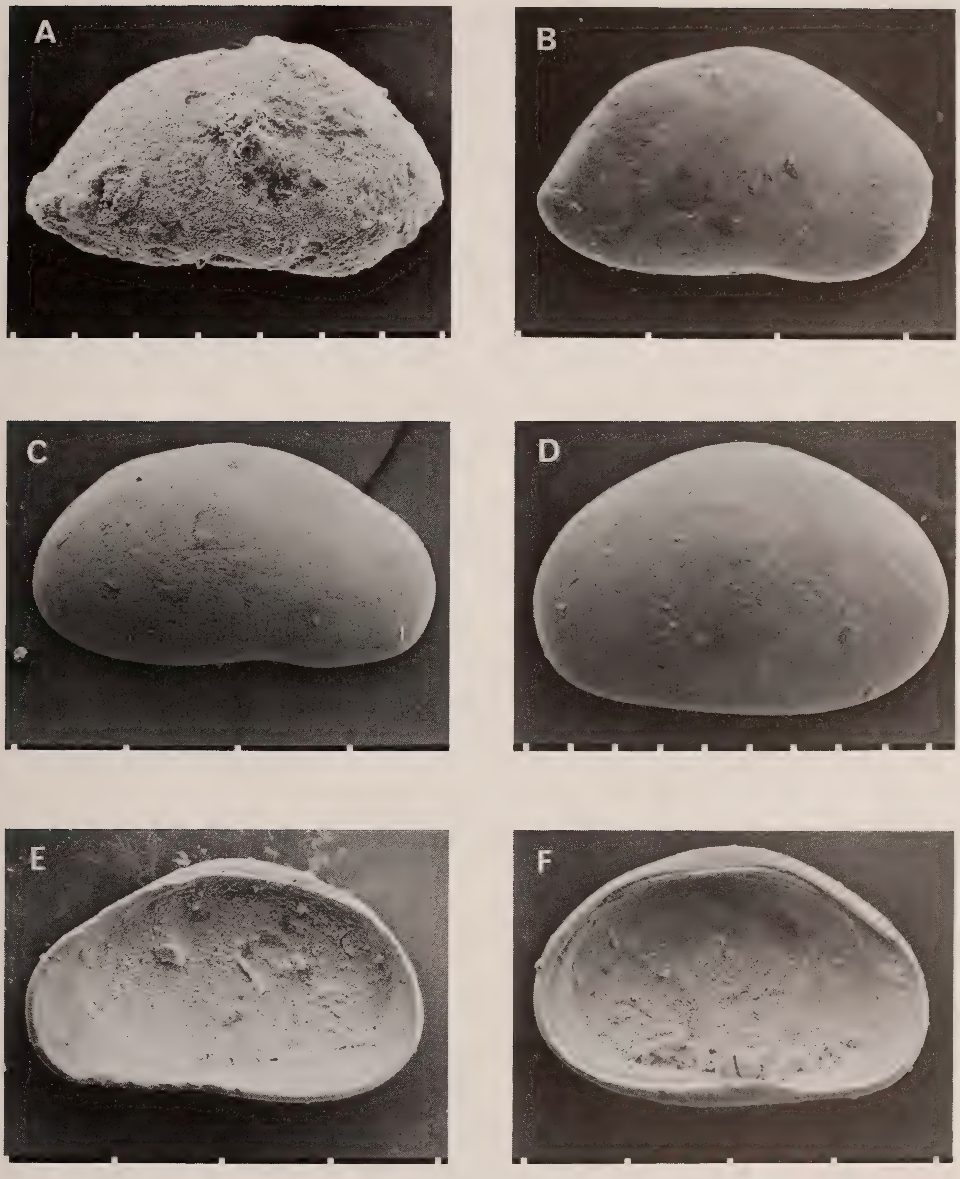


Fig. 8. A. *Bairdoppilata* sp. 1, SAM–PC6023, RV, locality 152, Mkuze, Zululand, Aptian IV. B. *Bairdoppilata* sp. 2, SAM–PC6024, RV, DSDP 330, core 1–1/112–116 cm, early–middle Albian. C–F. *Robsoniella falklandensis* sp. nov., DSDP 327, core 21–4/130–134 cm, early Albian. C. Holotype, SAM–PC6025, RV. D. SAM–PC6026, LV. E. SAM–PC6027, RV, internal view. F. SAM–PC6028, LV, internal view.
Scale bars: A, D = 100μ, others = 300μ.

in the latter), with *R. falklandensis* possessing no, or only very fine, RPC. Oertli (1974) records an apparently identical species from off-shore north-western Australia as indet sp. A (*?Robsoniella*), the only difference being the latter's apparently more strongly crenulate hinge elements. *R. falklandensis* differs from the genotype *R. obovata* Kusnetsova from the Aptian–Albian of the Caucasus in lacking well-defined RPC and in having a weaker hinge structure.

Asciocythere sp. 68, recorded by Damotte (1979) from the Aptian of DSDP 400A in north-western Bay of Biscay, has a very similar shape to *R. falklandensis*, but has a longer DM and narrow anterior MA.

Dimensions (mm)

	length	height
6025	1,08	0,60
6026	0,92	0,61
6027	1,08	0,68
6028	1,14	0,75

Age and distribution

R. falklandensis is by far the most abundant ostracod taxon in the early to late Albian of DSDP boreholes 327 and 330, where it occurs in every sample investigated except that from core 14–6/126–130 cm (Cenomanian), which did not contain ostracods. The species varies from 19 to 54% (average 35%) of total fauna at site 330, and from 15 to 70% (average 48%) at site 327.

Oertli (1974) recorded the species in four samples at DSDP site 260 (cores 9–11, Middle–Upper Albian) off north-western Australia, where it was also the dominant taxon.

Superfamily CYPRIDACEA Baird, 1845

Family **Paracyprididae** Sars, 1923

Genus *Paracypris* Sars, 1866

There was a marked disparity in the distribution of this genus in mid-Cretaceous times in the south-east Africa–Falkland Plateau area: it is sparse to abundant in Zululand, but has not been recorded from the Agulhas Bank or the Falkland Plateau. It may also be significant to note here that *Paracypris* is absent from the Portlandian to Hauterivian of the Algoa–Outeniqua basins (Dingle 1969; Brenner & Oertli 1976; McLachlan *et al.* 1976*b*), and only two valves were recorded from the Maastrichtian III of the Agulhas Bank, while the genus is relatively diverse and abundant in the Upper Cretaceous of Zululand (including the JC–1 borehole) (Dingle 1981). This strongly suggests latitudinal (thermal) control of the distribution of *Paracypris* in south-east Africa during Cretaceous times.

Paracypris sp.

Fig. 9A

Remarks

Although relatively abundant, specimens are poorly preserved, with good internal views not available. *Paracypris* sp. has a distinctive drawn-out PM and in this respect is very similar to *P. umzambaensis* Dingle. It may be a separate taxon because of its less symmetric DM outline, but MS patterns need to be seen to resolve the question.

Age and distribution

Paracypris sp. is known to range Aptian IV to Cenomanian III in Zululand, while its closest local relative (*P. umzambaensis*) is known from the Santonian to Maastrichtian in Zululand (Dingle 1981).

Superfamily CYTHERACEA Baird, 1850

There is a marked contrast in the importance of this superfamily between south-east Africa and the Falkland Plateau. In Zululand, cytheraceans (expressed as numbers of valves within the total ostracod population) dominate over the Cytherellidae and Bairdiacea–Cypridacea, whereas on the Falkland Plateau they are consistently subordinate to the Bairdiacea–Cypridacea elements. On the other hand, on the Falkland Plateau 89% of the species present are cytheraceans, whereas in Zululand they make up only 75% of the extant species. In other words, the Falkland Plateau cytheracean fauna is more diverse but numerically sparser than its Zululand counterpart. A further contrast is found on the Agulhas Bank, where cytheraceans constitute 100% of the ostracod population in Sample 1113, yet only two species account for 99%: an abundant but very restricted cytheracean element.

Family **Bythocytheridae** Sars, 1926

Genus *Monoceratina* Roth, 1928

Monoceratina? sp.

Fig. 9B

Remarks

One poorly preserved specimen showing the typical median sulcus and ventromedian projection of the genus. Hinge not observed, so generic placement is uncertain.

Age and distribution

Albian VI, Mzinene Formation at locality 178, Ndumu, Zululand.

Genus *Pariceratina* Gründel & Kozur, 1971

Pariceratina liebaui sp. nov.

Fig. 9C–D

?Nemoceratina (Pariceratina) sp. Liebau, 1977: 110–111, pl. 1C–F.

Derivation of name

After Dr A. Liebau, University of Tübingen, who first illustrated specimens probably belonging to this species.

Holotype

SAM–PC6031, LV, DSDP 36/330, core 1/cc, early–middle Albian.

Paratype

SAM–PC6032, LV, as for holotype.

Diagnosis

Species with lance-like posteroventral spine, prominent spine in anterodorsal area, and fan-like microconation on posterodorsal area.

Description

External features. Elongate quadrate. Rounded AM bearing numerous fine elongate spines, PM asymmetrically acuminate with apex above mid-height, posteroventral area spinose. DM straight, VM slightly concave about mid-length. Ventrolateral areas bear three conical elevations on a wide ridge: posterior elevation has a lance-like spine with numerous small spines around its base; median elevation is low with a small cluster of two to three spines; anterior elevation is larger with numerous small, stud-like spines. There is a prominent spine in the anterodorsal area which projects beyond the DM in lateral view. Surface ornamented with what Liebau (1977) terms microconate protoreticulation (string-of-beads-like muri), and occasional larger spines. The posterior part of the valve has a particularly delicate ornamentation with a fan-like arrangement of microconate strings on the posterior apex.

Internal features. MA moderately wide. Hinge simple and straight, with a smooth bar, slightly expanded anteriorly in LV and complementary groove in RV. MS not seen.

Remarks

P. liebaui is similar to *P. trispinosa* (Neale 1975) from the Santonian of western Australia, but the latter is less elongate and has a more rounded AM outline. The genus has been reported from the Maastrichtian of Zululand (*P. hirsuta*) by Dingle (1981), but this species has an overall spinose ornamentation and a somewhat different PM outline. Liebau (1977) illustrated two specimens from the Upper Aptian near Hanover, West Germany, that appear to be identical to our material.

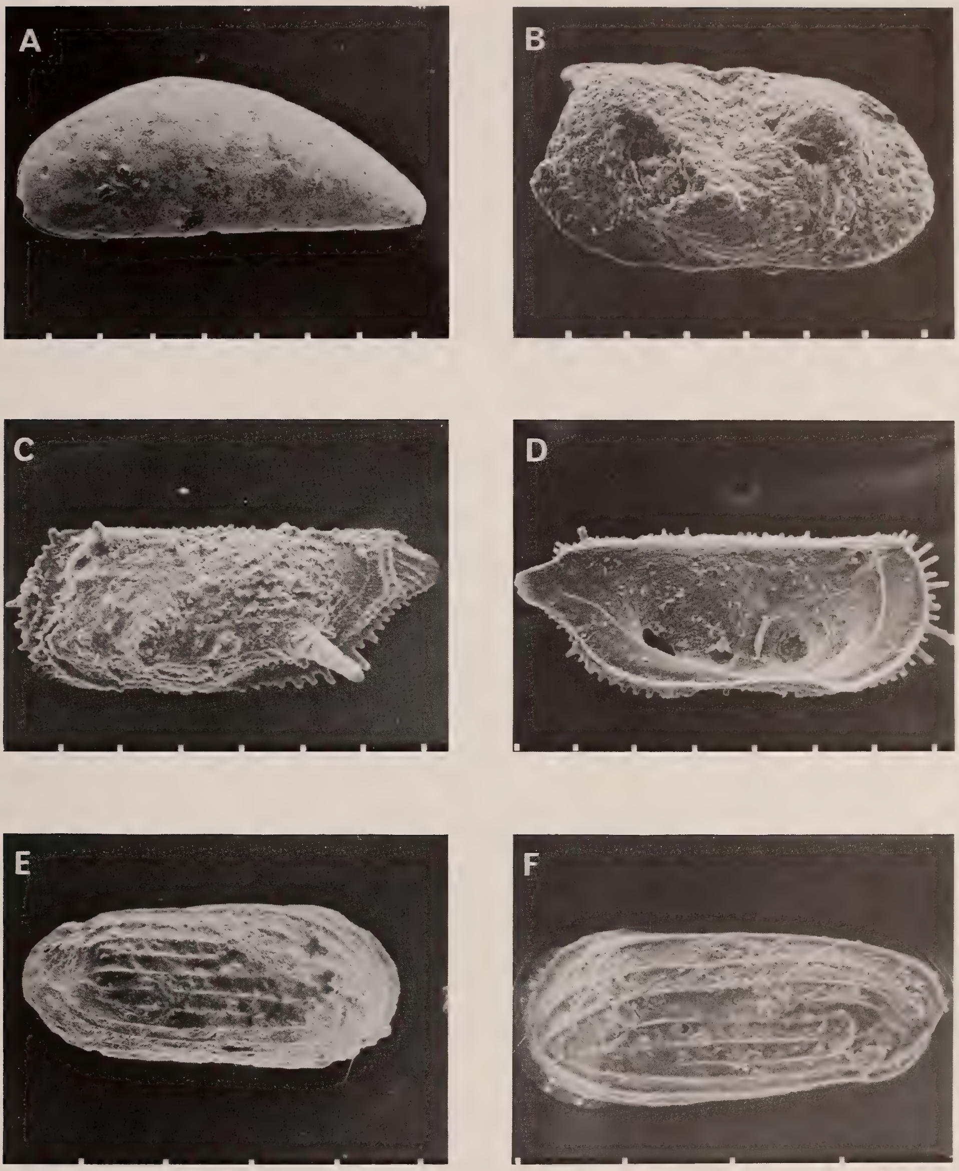


Fig. 9. A. *Paracypris* sp., SAM–PC6029, LV, locality 171–7, Mlambongwenya Spruit, Zululand, Albian II. B. *Monoceratina?* sp., SAM–PC6030, RV, locality 178, Msunduzi, Zululand, Albian VI. C–D. *Pariceratina liebaui* sp. nov., DSDP 330, core 1/cc, early–middle Albian. C. Holotype, SAM–PC6031, LV. D. SAM–PC6032, LV interior view. E–F. *Cytherura? oertlii* sp. nov., DSDP 327. E. Holotype, SAM–PC6033, RV, core 18–6/106–110 cm, middle Albian. F. SAM–PC6034, LV, core 15–2/132–136 cm, late Albian. Scale bars = 100 μ.

Dimensions (mm)

	length (incl. spines)	height
6031	0,72	0,28
6032	0,72	0,26
Liebau's specimen	0,79	0,28

Age and distribution

P. liebaui ranges early–middle Albian at DSDP site 330 (core 1–cc to 1–1/112–116 cm), and middle Albian at site 327 (core 16–1/55–59 cm), where it occurs in small numbers (1–3% total ostracod population at both sites).

Family **Cytheruridae** Müller, 1894

Subfamily Cytherurinae Müller, 1894

In Zululand, the subfamily Cytherurinae is represented by one species (*Procytherura* cf. *aerodynamica*) at one locality, where it accounts for only 2% of the total ostracod population. On the Falkland Plateau, on the other hand, the subfamily represents one of the most important elements of the ostracod population, 7 genera in 13 species, and these abundant micro-ostracods constitute one of the characteristic features of the Falkland Plateau Albian assemblages. Considered in terms of the total ostracod population, the Cytherurinae form 18% (mean of 3 samples) at site 330, and 5% (mean of 9 samples) at site 327, but as a percentage of the cytheraceans, they are 34% (max. 44%) at site 330, and 17% (max. 33%) at site 327.

Genus *Cytherura* Sars, 1866

Cytherura? oertlii sp. nov.

Figs 9E–F, 10

Indet sp. B. Oertli, 1974: 949, pl. 7 fig. 1.

Derivation of name

After Dr H. J. Oertli (Société Nationale Elf Aquitaine) who first recorded the species.

Holotype

SAM–PC6033, C, DSDP 36/327, core 18–6/106–110 cm, middle Albian.

Paratype

SAM–PC6034, C, DSDP 36/327, core 15–2/132–136 cm, late Albian.

Diagnosis

Elongate species, DM and VM parallel, ornamented with fine longitudinal ribs.

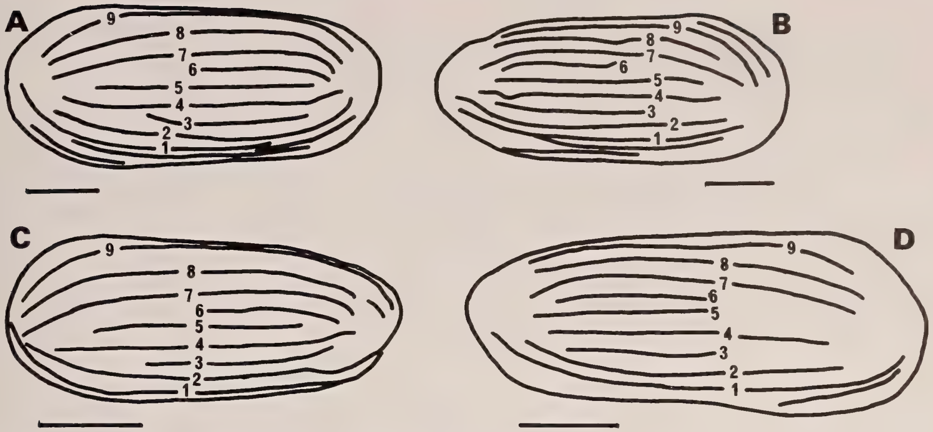


Fig. 10. Comparison of rib patterns in specimens of *Cytherura? oertlii* sp. nov. Numbering system has no significance other than to compare equivalent ribs. A. SAM–PC6034, LV, DSDP 327, core 15–2/132–136 cm, late Albian. B–C. Holotype, SAM–PC6033 RV(B), LV(C), DSDP 327, core 18–6/106–110 cm, middle Albian. D. Specimen illustrated by Oertli (1974, plate 7 (fig. 1)) as indet. sp. B from DSDP 260, core 9/cc, north-western Australia, Middle–Upper Albian. Scale bars = 100 μ.

Description

External features. Small, elongate, DM and VM parallel, asymmetrically rounded AM, narrower, slightly acuminate PM with incipient caudal process. Valve surface ornamented with nine fine longitudinal ribs, the most prominent being numbers 1, 2, 4, 7, 8, and 9 (see Fig. 10). In LV, rib 1 curves partly round the AM area, and in both valves the lower two ribs converge posteriorly with the upper three.

Internal features. None available.

Remarks

Tentatively placed in *Cytherura* on valve shape and ornamentation. Oertli's (1974) specimen from off-shore western Australia has an identical rib pattern to *C? oertlii* (Fig. 10).

Dimensions (mm)

	length	height
6033	0,53	0,23
6034	0,40	0,16
Indet. sp. B. Oertli, 1974	0,47	0,18

Age and distribution

C? oertlii ranges middle to late Albian in DSDP 327 (cores 18–6/106–110 cm to 15–2/132–136 cm), where it is rare (3–5%), and Middle–Upper Albian in DSDP 260 (core 9/cc) off north-western Australia.

Genus *Eucytherura* Müller, 1894

Eucytherura rugosa sp. nov.

Fig. 11A–C

Derivation of name

Latin *rugosa* (rough): reference to rough, corrugated surface ornamentation.

Holotype

SAM–PC6035, LV, DSDP 36/330, core 1/cc, early–middle Albian.

Diagnosis

Species with wedge-shaped eye tubercle, coarsely reticulate surface ornamentation, and posteriorly deflected ala termination.

Description

External features. Subquadrate outline. Broadly rounded AM with a few short, stout, sharp spines anteroventrally, straight DM, pointed PM with apex in line with DM. VM almost straight, converging slightly with DM. There is a large wedge-shaped eye tubercle below the anterior CA, and a smaller wedge-shaped elevation at the posterior CA. A sharp, rugose ventrolateral ridge lies on the upper edge of a prominent ala terminating posteriorly in a rough, blade-like spine. A similar second spine lies along the trailing edge of the ala, whose ventral surface has several low ridges. The valve surface overall is covered by coarse reticulation bearing small mural spines. Over the posterior part of the ala this reticulation takes the form of transverse corrugation.

Internal features. MA wide (RPC not seen). MS not seen. Hinge in LV consists of a crenulate median bar and small, rounded TE.

Remarks

E. rugosa closely resembles *E. stellifera* sp. nov. from DSDP 327, but differs on the following points: different reticulate ornamentation pattern; the eye tubercle of *E. stellifera* projects forward; and the ventrolateral ridge of *E. stellifera* is more sharply defined and lies in a more median position in its anterior part. In addition, the ATE RV hinge of *E. rugosa* consists of a rounded pit, compared to a more elongate socket that lies partly above the anterior end of the ME in *E. stellifera*. Bate (in Bate & Bayliss 1969) recorded *E. tanzanensis* from the Upper Aptian of Tanzania but, although it also possesses a coarse reticulate ornamentation, it differs from *E. rugosa* in shape, particularly the PM.

Dimensions (mm)

	length	height
6035	0,24	0,14

Age and distribution

E. rugosa is known only from the early–middle Albian of DSDP 330 (core 1/cc) on the Falkland Plateau.

Eucytherura stellifera sp. nov.

Fig. 11D–F

Derivation of name

Latin *stellifera* (starry, star-bearing): reference to star-like pattern of mural spines.

Holotype

SAM–PC6036, LV. DSDP 327, core 21–3/71–76 cm, early Albian.

Diagnosis

Species with reticulate ornamentation that has a stellate orientation of mural spines.

Description

External features. Subquadrate in lateral view, slightly asymmetrically rounded AM, straight DM, acuminate PM with apex along line of DM, VM almost straight. Eye tubercle is large and angular, has a somewhat twisted appearance, and projects slightly forward. There is a low elongate swelling over the posterior CA. Ventrolaterally the valve is inflated and alate, with a short terminal spine projecting posteriorly. The ala has a ribbed leading edge that extends forward into the anterior quarter of the valve. A second blade-like spine occurs on the ala trailing edge. Entire lateral valve surface ornamented with a coarse reticulation that is particularly well developed in the median areas. Muri bear short, sharp spines that project inward, producing a stellate arrangement.

Internal features. No MA or MS seen. Hinge in LV consists of a long straight crenulate bar, a small elongate indistinct PTE, and a small ATE that extends over the dorsal end of the ME.

Remarks

E. stellifera is very close to *E. rugosa* and differs primarily on ornamentation, although other differences have been listed under the *Remarks* section for the latter species. The ornamentation of *E. tanzanensis* Bate from the Upper Aptian of Tanzania is similar to that of *E. stellifera*: 'small denticular processes grow into the 5–6 sided pits', but this species has only a small eye tubercle, and differs considerably in outline, especially the PM. Similarly, *E. antipodum* Neale, 1975, from the Santonian of western Australia has a well-developed reticulate ornamentation, but differs from *E. stellifera* in details of ala shape, PM outline, and size of eye tubercle.

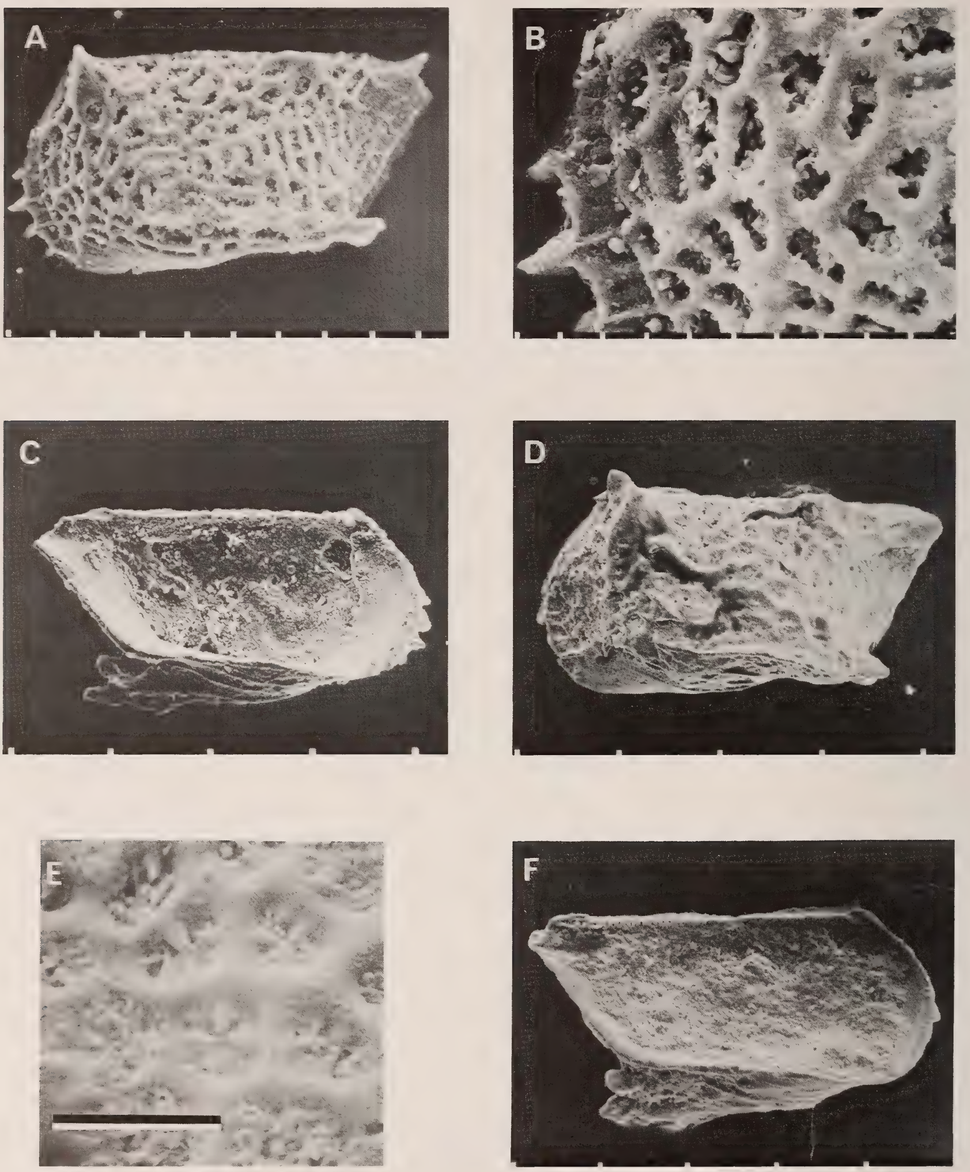


Fig. 11. A–C. *Eucytherura rugosa* sp. nov., holotype, SAM–PC6035, LV, DSDP 330, core 1/cc, early–middle Albian. A. External view. B. Detail of anterior area. C. Internal view. D–F. *Eucytherura stellifera* sp. nov., holotype, SAM–PC6036, LV, DSDP 327, core 21–3/71–76 cm, early Albian. D. External view. E. Detail of ornamentation, central part of valve. F. Internal view.
Scale bars: A, E = 30μ, C–D, F = 100μ.

Dimensions (mm)

	length	height
6036	0,34	0,21

Age and distribution

E. stellifera is known only from the early Albian of DSDP 327 (core 21–3/71–76 cm) on the Falkland Plateau.

Genus *Procytherura* Whatley, 1970, emend. Bate & Coleman, 1975

Procytherura cf. *P. aerodynamica* Bate, 1975

Fig. 12A

Remarks

A single broken valve that has a similar outline to that of *P. aerodynamica* Bate from the Lower–Upper Kimmeridgian of Tanzania. The specimen is closest to that illustrated in plate 11 (fig. 11) of Bate (1975) (which was regarded as a juvenile), but differs in being more acuminate posteriorly than the east African form.

Brenner & Oertli (1976) described three species of *Procytherura (maculata, beerae, dinglei)* from the Lower Sundays River Formation (Upper Valanginian to Lower Hauterivian) of the Algoa Basin (south-east Africa), but all three have distinct ornamentation, whereas the specimen from Zululand is smooth.

Age and distribution

Aptian IV, Makatini Formation, locality 171 at Mlambongwenya Spruit, northern Zululand.

Procytherura batei sp. nov.

Fig. 12B–C, E

Derivation of name

After Dr R. H. Bate (previously of the British Museum (Nat. Hist.)) for his contribution to knowledge of east African Mesozoic Ostracoda.

Holotype

SAM–PC6038, LV, DSDP 36/327, core 16–4/66–70 cm, middle Albian.

Paratypes

SAM–PC6039, LV, as above.
SAM–PC6040, C, as above.

Diagnosis

Ovate species with pointed PM, punctate, weakly reticulate ornamentation, and bevelled AM and PM borders.

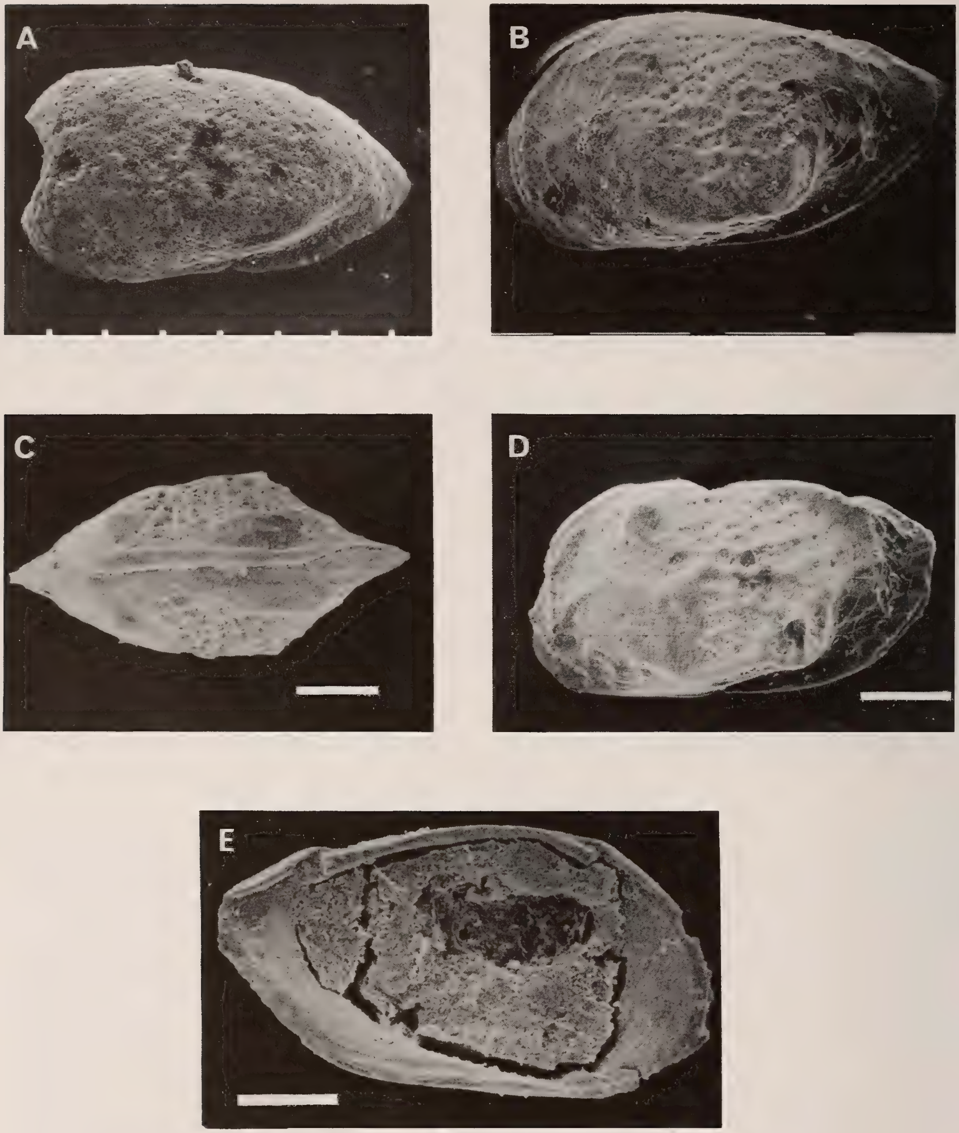


Fig. 12. A. *Procytherura* cf. *P. aerodynamica* Bate, 1975, SAM–PC6037, LV, locality 171–1, Mlambongwenya Spruit, Zululand, Aptian IV. B–C, E. *Procytherura batei*, sp. nov., DSDP 327, core 16–4/66–70 cm, middle Albian. B. Holotype, SAM–PC6038, LV. C. SAM–PC6040, C, dorsal view, anterior to the left. E. SAM–PC6039, LV, internal view. D. *Procytherura* cf. *P. dinglei* Brenner & Oertli, 1976, SAM–PC6041, DSDP 327, core 16–6/126–130 cm, middle Albian.
Scale bars = 100 μ.

Description

External features. Ovate, with rounded AM, PM asymmetrically acuminate with rounded apex above mid-height. DM weakly convex, VM straight, DM and VM converge slightly posteriorly. AM and PM have a narrow bevelled border. Greatest height in anterior third. There is a prominent ventrolateral swelling, giving the valve an almost alate appearance. A small angular eye swelling occurs just below the anterior CA of each valve. Surface punctate with indistinct reticulation that is best developed in posterior areas. In dorsal view carapace is almost diamond-shaped, with a prominent RV on to LV overlap along DM. DM in RV has a thicker rim.

Internal features. Hinge holoperatodont, with thickening of LV ME that turns down at its anterior end. MS not seen. MA wide, but details not seen.

Remarks

P. batei is a typical member of the genus, and is closest to *P. maculata* Brenner & Oertli (1976) from the Hauterivian of the Algoa Basin. The latter has a concave VM, and has its posterior apex at about mid-height. *P. batei* is also similar to a species recorded as *Paijenborchellina* sp. 1 Swain by Damotte (1979) from the early–late Aptian of DSDP 402A (core 34/CC) on the continental slope in the northern Bay of Biscay. Comparison with Swain's (1976) figures suggests that Damotte's specimen is not conspecific, and probably not a *Paijenborchellina*, but rather belongs to *Procytherura*. It differs from *P. batei* in possessing weak longitudinal ribbing, especially in the anterior half.

Dimensions (mm)

	length	height	width
6038	0,45	0,23	
6039	0,43	0,25	
6040	0,49		0,16

Age and distribution

P. batei is known from the early–middle Albian of DSDP 330 (core 2–2/122–126 cm), and middle Albian of DSDP 327 (core 16–4/66–70 cm). It is rare (*c.* 3 % total ostracod population) in the former, and relatively abundant (18 %) in the latter.

Procytherura cf. *P. dinglei* Brenner & Oertli, 1976

Fig. 12D

Remarks

P. dinglei was recorded by Brenner & Oertli (1976) from the Hauterivian of the Algoa Basin (south-east Africa). Our material consists of one slightly damaged valve from the Falkland Plateau. Externally the specimen has a very similar outline and ornamentation to *P. dinglei*, including the rather irregular surface of the ventrolateral swelling in the posterior half of the valve. The only significant point of difference is the somewhat smoother shell surface of the anterior part of the valve in the DSDP specimen.

Interior details in *P.* cf. *P. dinglei* are not well preserved, but show a typical holoperatodont hinge, although there is a suggestion of crenulation on the posterior part of the LV ME (which may be due to abrasion). Brenner & Oertli (1976) did not record internal details in their topotypes.

Dimensions (mm)

	length	height
6041	0,45	0,25

On a length–height scattergram, this specimen plots precisely within the field defined by Brenner & Oertli's population (1976, fig. 27).

Age and distribution

P. cf. *P. dinglei* is known from a single LV in the middle Albian of DSDP 327 (core 16–6/126–130 cm) on the Falkland Plateau. *P. dinglei* is known only from the Hauterivian of the Algoa Basin.

Genus *Cytheropteron* Sars, 1866

Cytheropteron bispinosa sp. nov.

Fig. 13A–D

Derivation of name

Latin *bispinosa* (two spines): reference to two spines on the alae.

Holotype

SAM–PC6042, LV, DSDP 36/330, core 1–1/112–116 cm, early–middle Albian.

Paratypes

SAM–PC6043, RV, as above.
SAM–PC6044, LV, as above.
SAM–PC6045, LV, as above.

Diagnosis

Species with blunt alae that typically bear two short spines at their posterior ends.

Description

External features. Elongate ovate in lateral outline. AM rounded, somewhat truncated anteroventrally, acuminate PM, caudal process slightly upturned. DM and VM broadly convex, former has a prominent rim. Alae blunt and wedge-

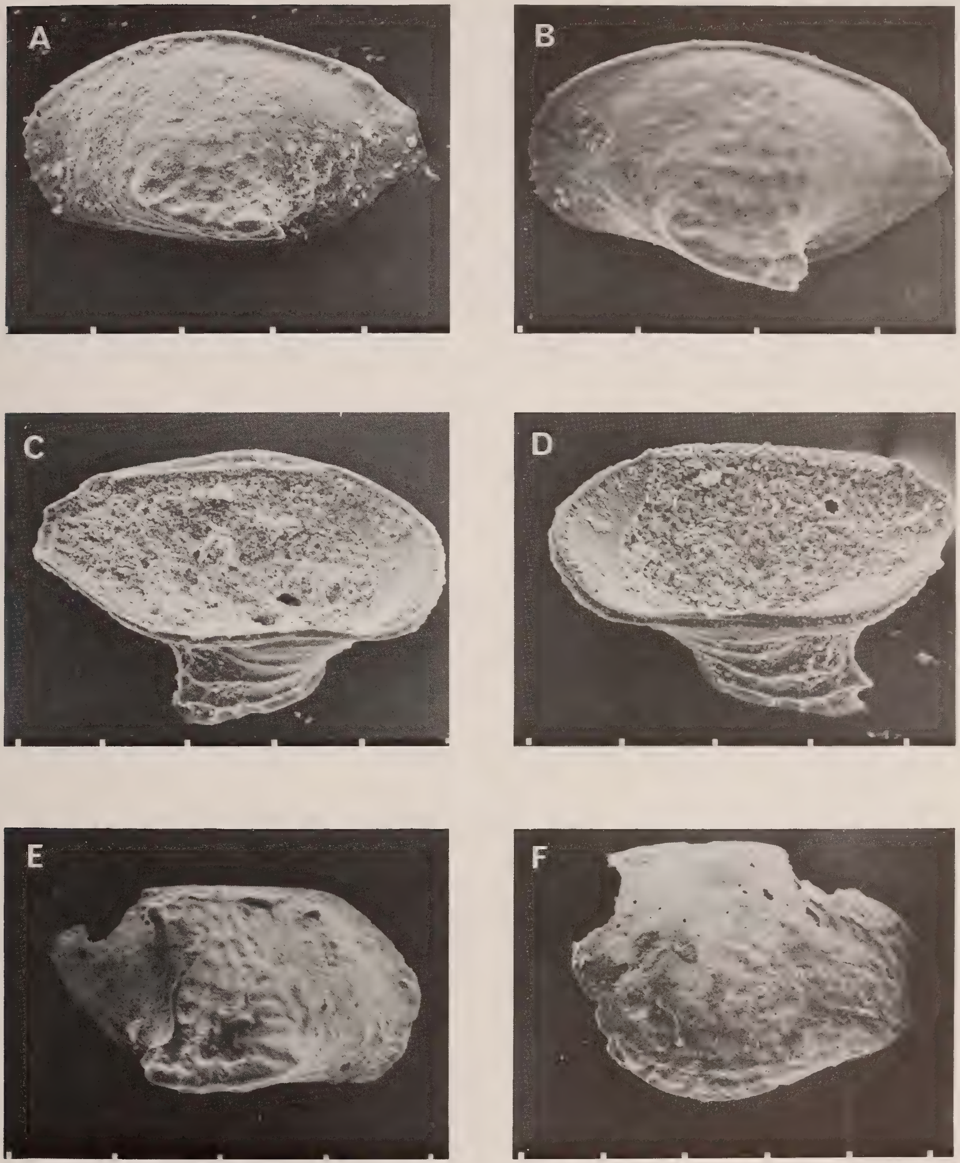


Fig. 13. A–D. *Cytheropteron bispinosa* sp. nov., DSDP 330, core 1–1/112–116 cm, early–middle Albian. A. Holotype, SAM–PC6042, LV. B. SAM–PC6044, LV. C. SAM–PC6045, LV, internal view. D. SAM–PC6043, RV, internal view. E. *Cytheropteron* sp. 327/18, SAM–PC6046, RV, DSDP 327, core 18–2/51–55 cm, middle Albian. F. *Cytheropteron* sp., SAM–PC6047, RV, TBD 1113, Agulhas Bank, Middle–Upper Albian.
Scale bars = 100 μ.

shaped with a short ribbed leading edge. Trailing edge bears two short, wide, sharp spines, one at the extremity, the other just inboard at the end of a narrow ventral surface rib. There are three other ribs on the ventral surface. Overall, valve surface smooth except for faint coarse reticulation on upper surface of alae.

Internal features. MA broad, MS not seen. Hinge typical of genus, with two smooth TE and crenulate ME.

Remarks

C. bispinosa resembles *C. (Aversovalva) mccomborum* Neale (1975) from the Santonian of western Australia, but the latter has trispinose alae and overall punctation.

Dimensions (mm)

	length	height
6042	0,43	0,23
6043	0,43	0,20
6044	0,35	0,18

Age and distribution

C. bispinosa ranges early–middle Albian in DSDP 330 (core 1/cc–112–116 cm), and middle Albian in DSDP 327 (core 18–2/51–55 cm to 16–1/55–59 cm) on the Falkland Plateau. It is recorded from five levels in these two boreholes, and is common in site 330 (10–13%) and rarer in site 327 (3–6%).

Cytheropteron sp. 327/18

Fig. 13E

Remarks

Two valves of a subquadrate species of *Cytheropteron* that has an asymmetrical, bluntly rounded AM and a more acuminate PM. The alae are blunt, with a thick leading edge. Ala shape is reminiscent of that of *C. bispinosa* sp. nov. but valve outline of the two species differs considerably.

Age and distribution

Ranges middle Albian in DSDP 327 (cores 18–2/51–55 cm to 16–6/126–130 cm) on the Falkland Plateau.

Cytheropteron sp.

Fig. 13F

Remarks

Dingle (1971: 396) listed this fragmentary specimen (as *Cytheropteron?* sp.) from sample TBD 1113 on the Agulhas Bank, but did not illustrate or give any details of it. An SEM photograph shows that it has a broad, keeled ala projecting almost to the AM. The rest of the valve is pitted and broken. The genus *Cytheropteron* is not well represented in the Lower and mid-Cretaceous of south-east Africa, with only one species (*C. (Infracytheropteron) persica* Brenner & Oertli) reported from the Upper Valanginian to Hauterivian of the Algoa Basin (*c.* 1%) (Brenner & Oertli 1976) and Outeniqua Basin (McLachlan *et al.* 1976*b*). The specimen illustrated here differs in both ala outline and ornamentation from *C. (I.) persica, C. bispinosa*, and *C.* sp. 327/18.

Age and distribution

Known only from the Middle–Upper Albian of the Agulhas Bank (sample TBD 1113).

Genus *Hemingwayella* Neale, 1975

Subgenus ***Parahemingwayella*** subgen. nov.

Derivation of name

Generic name *Hemingwayella* + ‘para’ to denote closeness of new taxon to genotype *H. (H.) ornata* Neale 1975.

Type species

H. (P.) barkeri sp. nov.

Diagnosis

Subgenus of *Hemingwayella* that is blind.

Remarks

Neale (1975) erected the genus *Hemingwayella* to accommodate a species that fell within the so-called *Paracytheridea* subgroup of Hanai (1957) but could not be placed within existing genera such as *Paracytheridea, Eucytherura*, and *Paracytheropteron*. The new subgenus *Parahemingwayella* is erected to accommodate three species that fulfill most of the prerequisites of Neale’s diagnosis but differ on a few significant points. The most important is blindness, but there are also minor features such as a slightly flexed DM (including a distinctive kink in the hinge ME), and converging DM and VM. The considerable difference in age between the known species of the genus suggest that *H. (Parahemingwayella)* was ancestral to *H. (Hemingwayella)*.

Age and distribution

The subgenus *Parahemingwayella* is known only from the early to middle Albian of the Falkland Plateau, while the subgenus *Hemingwayella* is known only from the Santonian of western Australia.

Hemingwayella (Parahemingwayella) barkeri sp. nov.

Fig. 14A–C

Derivation of name

After Dr P. Barker, co-chief scientist of DSDP Leg 36 to the Falkland Plateau.

Holotype

SAM–PC6048, RV, DSDP 330, core 1/cc, early–middle Albian.

Paratype

SAM–PC6049, LV, as above.

Diagnosis

Species with two prominent ventrolateral processes.

Description

External features. Elongate, subtriangular in lateral view. AM broadly rounded, weakly spinose, PM small, bluntly rounded, slightly upturned. DM flexed at about mid-length, which in RV produces a posteriorly directed step. VM straight to weakly convex. DM and VM converge posteriorly. Highest point of valve over prominent anterior CA. Surface features dominated by a large, rounded, ribbed median–ventrolateral to subcentral process, and a more diffuse elliptical ribbed posteroventral swelling which is posteriorly directed. A prominent rib runs diagonally from the posterior CA, round the dorsal side of the subcentral process, and in some specimens, to the subcentral part of the AM. A second prominent rib skirts the ventral side of the subcentral process and passes across the crest of the posteroventral swelling. Several smaller longitudinal ribs occur in the ventral and posterior parts of the valve surface. Other areas are weakly reticulate and strongly punctate. There is a median sulcus.

Internal features. MA wide, MS not seen. Hinge in RV consists of sinuous, narrow, finely crenulate ME groove with narrow, smooth outward-projecting ATE and PTE.

Remarks

H. (P.) barkeri differs from *H. (H.) ornata* Neale in shape of DM and AM, and in having a continuation of the diagonal longitudinal rib to the posterior CA; in *H. (H.) ornata* this rib runs only to a mid-height position. Average length–height ratios for the two species are 1,52 (*ornata*) and 1,98 (*barkeri*).

Dimensions (mm)

	length	height
6048	0,32	0,15
6049	0,42	0,21

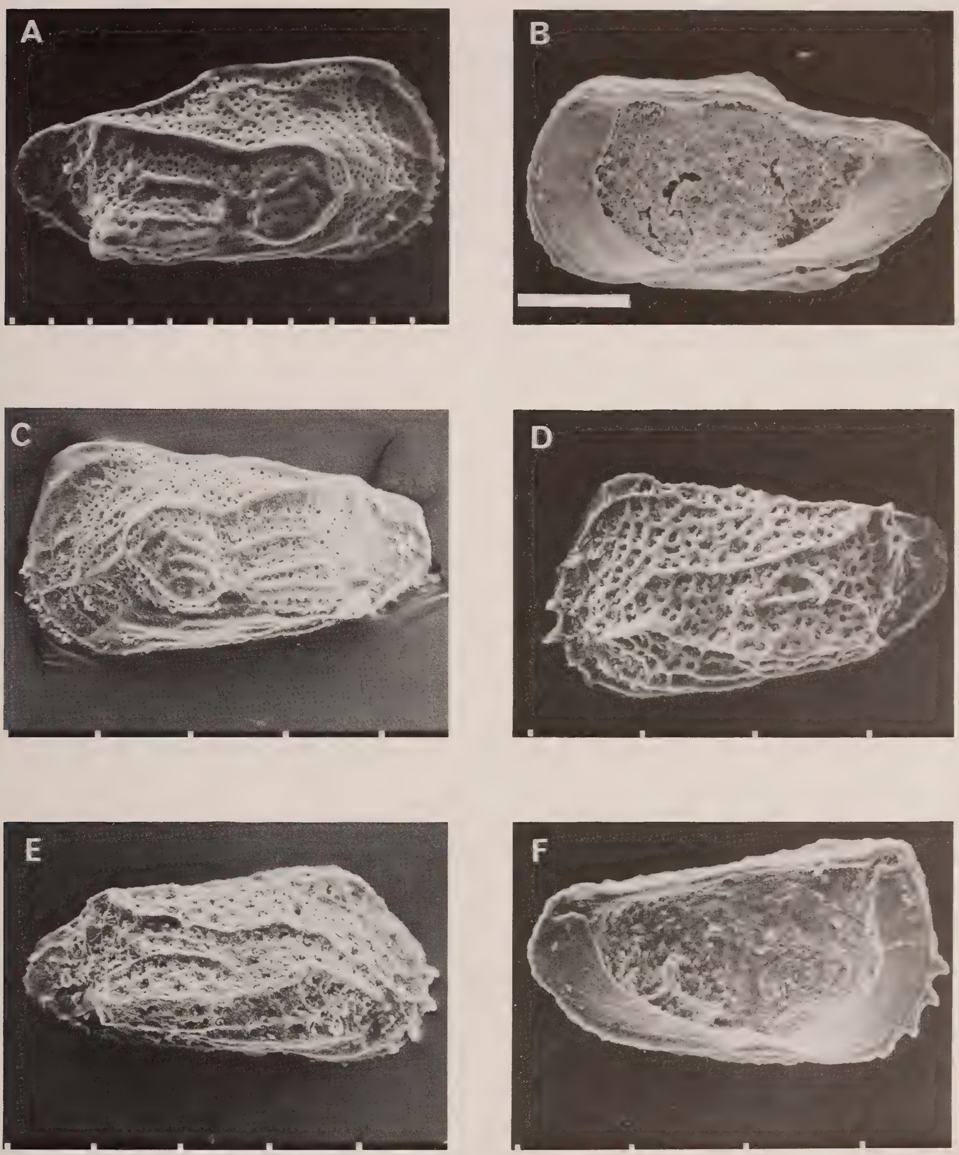


Fig. 14. A–C. *Hemingwayella (Parahemingwayella) barkeri* subgen. et sp. nov., DSDP 330, core 1/cc, early–middle Albian. A–B. Holotype, SAM–PC6048, RV. A. External view. B. Internal view. C. SAM–PC6049, LV. D–F. *Hemingwayella (Parahemingwayella) dalzieli* subgen. et sp. nov., DSDP 330, core 1, early–middle Albian. D. Holotype, SAM–PC6050, LV, core cutter. E. SAM–PC6051, RV, section 1/112–116 cm. F. SAM–PC6052, LV, core cutter, internal view.
Scale bars: A = 30μ, others = 100μ.

Age and distribution

H. (P.) barkeri is known from the early–middle Albian of DSDP site 330 (core 1/cc), and middle Albian of DSDP 327 (core 16–4/66–70 cm) on the Falkland Plateau, where it is a rare species (*c.* 3% at both sites).

Hemingwayella (Parahemingwayella) dalzieli sp. nov.

Figs 14D–F, 15A

Derivation of name

After Dr I. Dalziel, co-chief scientist of DSDP Leg 36 to the Falkland Plateau.

Holotype

SAM–PC6050, LV, DSDP 330, core 1/cc, early–middle Albian.

Paratypes

SAM–PC6051, RV, DSDP 330, core 1–1/112–116 cm, early–middle Albian.
SAM–PC6052, LV, DSDP 330, core 1/cc, early–middle Albian.
SAM–PC6053, RV, DSDP 330, core 1/cc, early–middle Albian.

Diagnosis

Species with subcentral process, coarsely spinose AM, valve surface coarsely reticulate with two prominent converging longitudinal ribs.

Description

External features. Elongate, subtriangular in lateral view. AM broadly rounded with a few sharp, stubby, almost hook-like spines, PM narrow and rounded. DM almost straight, slightly flexed at about mid-length. VM straight to slightly convex, DM and VM converge posteriorly. Subcentral process indistinct, but large and rounded, posteroventral process elongate and outlined by several longitudinal ribs. Surface features dominated by two narrow longitudinal ribs: one runs diagonally from the posterior CA to the dorsal side of the subcentral process, skirts it and continues to the AM; the other runs from the outer edge of the posteroventral process to the ventral side of the anteroventral process, is deflected dorsally across the crest of the anteroventral process, and continues parallel to the median rib to the AM area. A short posteromedian, and two ventral longitudinal ribs are also typically present. Highest point lies over the anterior CA. There is a shallow median sulcus.

Internal features. Reverse of the exterior median sulcus is well developed. MA wide, particularly posteriorly. MS not seen. NPC prominent. Hinge in LV consists of an ME bar with slight median flexing, and two small terminal elements that are wrapped round by the MA. RV structures are complementary. ME are probably crenulate.

Remarks

H. (P.) dalzieli is close to *H. (P.) barkeri*, but the former can be distinguished from the latter by its poorly developed subcentral process, its less-flexed DM, its more angular posterior CA, and the presence of two converging longitudinal ribs, the ventral one of which has a distinctive flexure at about quarter length. Average length–height ratios are: 1,99 (*barkeri*) and 1,91 (*dalzieli*) (Fig. 16).

Dimensions (mm)

	length	height
6050	0,34	0,20
6051	0,46	0,21
6052	0,35	0,19
6053	0,35	0,18

Age and distribution

H. (P.) dalzieli is known only from the early–middle Albian at DSDP site 330 (core 1/cc and 1–1/112–116 cm), where it is relatively abundant (*c*. 10% and 6%, respectively).

Hemingwayella (Parahemingwayella) reticulata sp. nov.

Fig. 15B–D

Derivation of name

Latin *reticulata* (reticulate): reference to ornamentation.

Holotype

SAM–PC6054, LV, DSDP 330, core 1/cc, early–middle Albian.

Paratype

SAM–PC6055, RV, as above.

Diagnosis

Reticulate species with well-developed mural spines.

Description

External features. Elongate, subtriangular. AM broadly rounded with several stout, short, frequently hooked spines, PM narrow, rounded. DM almost straight in LV, distinctly flexed in RV. VM straight, converges posteriorly with DM. Subcentral process very weakly developed, separated from a more prominent posteroventral process by a median sulcus. The latter process bears a few stubby spines. There is a well-developed spinose, conical process just below the posterior CA and a similar but smaller elevation at the anterior CA. Surface

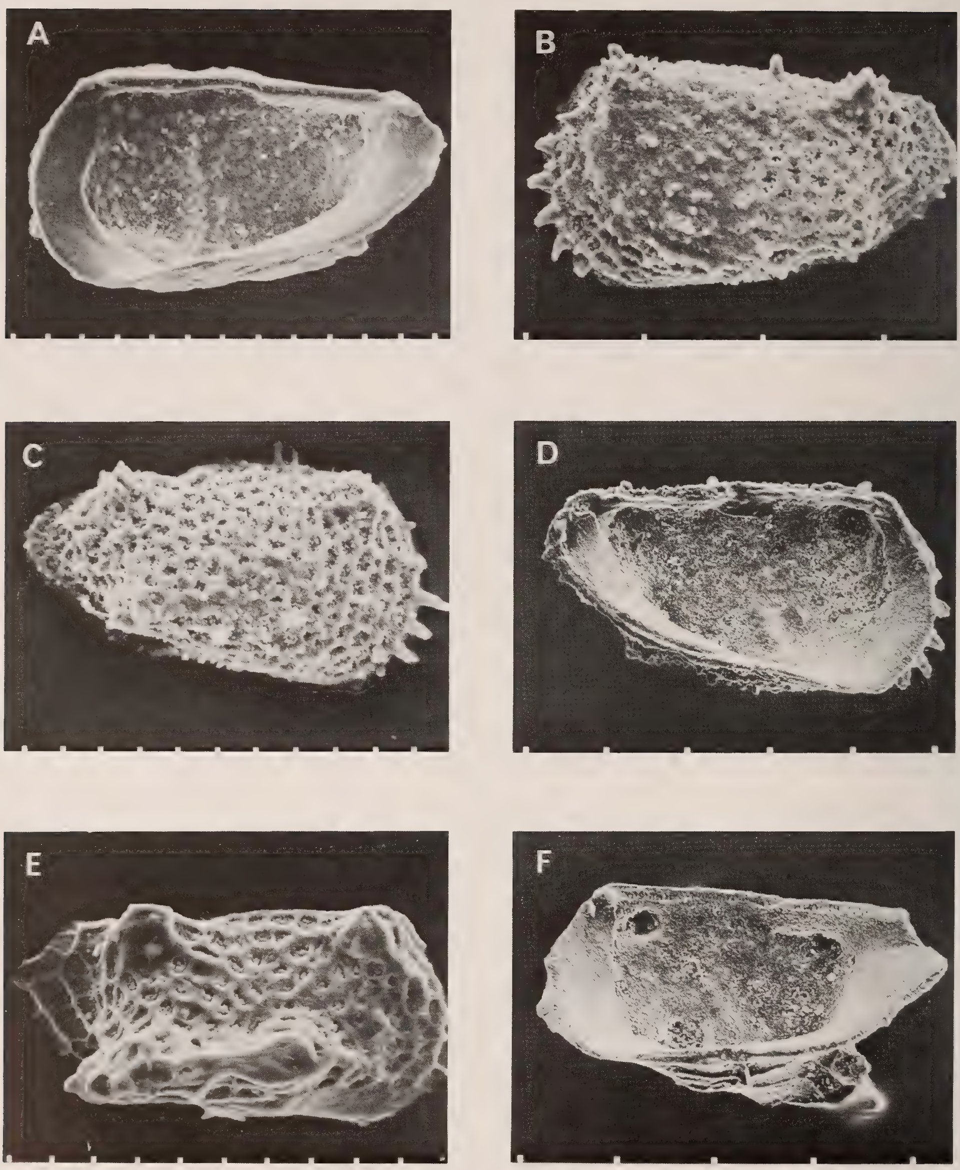


Fig. 15. A. *Hemingwayella (Parahemingwayella) dalzieli*, subgen. et sp. nov., SAM–PC6053, RV, DSDP 330, core 1/cc, early–middle Albian, internal view. B–D. *Hemingwayella (Parahemingwayella) reticulata,* subgen. et sp. nov., DSDP 330, core 1/cc, early–middle Albian. B, D. Holotype, SAM–PC6054. B. LV. D. Internal view. C. SAM–PC6055, RV. E–F. *Hemiparacytheridea ewingensis* sp. nov,. DSDP 330, core 1/cc, early–middle Albian. E. Holotype, SAM–PC6056, RV. F. SAM–PC6057, RV, internal view. Scale bars: A, C, E = 30μ, B, D, F = 100μ.

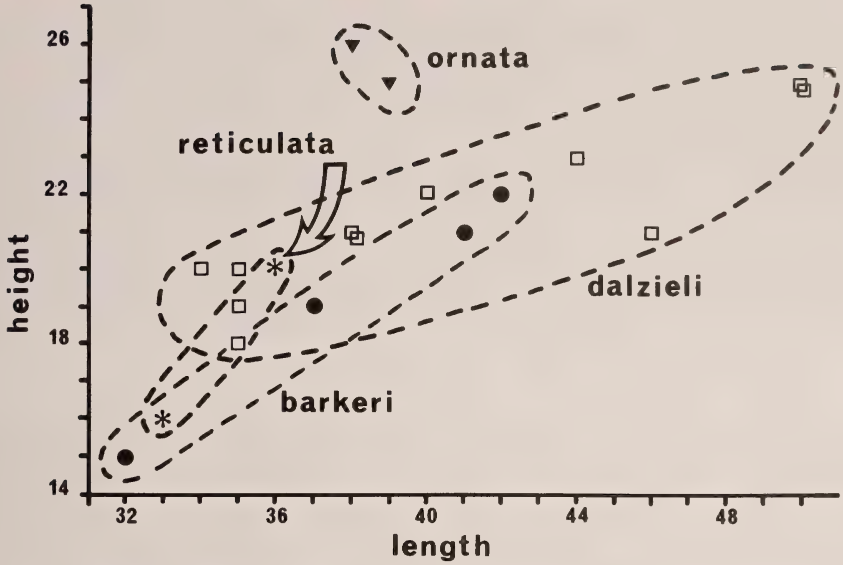


Fig. 16. Length v. height scattergram of adult specimens belonging to the genus *Hemingwayella* Neale, 1975 (scale ×10μ). Triangles: *H. (H.) ornata* Neale, 1975, western Australia, Santonian. Squares: *H. (P.) dalzieli* sp. nov., Falkland Plateau, early–middle Albian. Circles: *H. (P.) barkeri* sp. nov., Falkland Plateau, early–middle Albian. Stars: *H. (P.) reticulata* sp. nov., Falkland Plateau, early–middle Albian.

overall reticulate, with well-developed mural spines imparting a rough aspect to valve surface.

Internal features. MA moderate to broad. Median sulcus and processes on exterior surface have prominent counterparts in internal view. Hinge consists of a long flexed ME (bar in RV), and short, narrow TE. All elements are apparently smooth, but may be worn. MS not seen.

Remarks

H. (P.) reticulata is similar in outline to *H. (P.) dalzieli* but differs significantly in ornamentation: *reticulata* is reticulate overall with mural spines; *dalzieli* is reticulate, but also has several longitudinal ribs and does not have mural spines.

Dimensions (mm)

	length	height
6054	0,36	0,20
6055	0,33	0,16

Age and distribution

H. (P.) reticulata is known only from the early–middle Albian of DSDP 330 (core 1/cc and 1–1/112–116 cm) where it is rare (1–3%).

Genus *Hemiparacytheridea* Herrig, 1963

Hemiparacytheridea ewingensis sp. nov.

Fig. 15E–F

Derivation of name

Locality of type specimen on Maurice Ewing Bank, Falkland Plateau.

Holotype

SAM–PC6056, RV, DSDP 330, core 1/cc, early–middle Albian.

Paratype

SAM–PC6057, RV, as above.

Diagnosis

Species with large eye tubercle and large subcubic process over posterior CA. Surface coarsely reticulate.

Description

External features. Subquadrate in lateral outline. AM broadly rounded, PM asymmetrically pointed with apex above mid-height. DM and VM straight, converging posteriorly. There is a large eye-spot and a similarly shaped feature over posterior CA. The ala is prominent and extends foward via a ridge to a large swelling at about third length. Surface coarsely reticulate.

Internal features. MA wide both anteriorly and posteriorly. The inner valve surface has four large hollows corresponding to the protuberences on the exterior surface. MS not seen. Hinge in RV consists of a long, straight, finely crenulate ME groove and small rounded ATE. PTE not preserved.

Remarks

Externally, *H. ewingensis* bears a resemblance to *H. hemingwayi* Neale, 1975, from the Santonian of western Australia, but the latter is more elongate and has a higher PM apex. The hinge of our species is very similar to the type species (*H. occulta* Herrig, 1963, Upper Maastrichtian of Rugen Island, East Germany), but lacks the anterior ME enlargement, and has a less pronounced convergence of the DM and VM. Similarities with *H. challengeri* will be discussed below.

Dimensions (mm)

	length	height
6056	0,29	0,15
6057	*c*. 0,25	0,13

Age and distribution

H. ewingensis is a rare species (*c*. 2%) known only from the early–middle Albian at one horizon in DSDP 330 (core 1/cc) on the Falkland Plateau.

Hemiparacytheridea challengeri sp. nov.

Fig. 17A

Derivation of name

From the drilling ship *Glomar Challenger*, which drilled DSDP sites on the Falkland Plateau.

Holotype

SAM–PC6058, LV, DSDP 330, core 1–1/112–116 cm, early–middle Albian.

Diagnosis

Reticulate species with prominent longitudinal median rib, a pointed symmetrical PM, and a pyramid-shaped posterodorsal process.

Description

External features. In lateral view elongate quadrate, broadly rounded AM and symmetrically pointed PM. DM straight, but deflected at anterior CA over prominent eye-spot. There is a large pyramid-shaped process at the posterior CA, which has a narrow anteriorly projecting ridge that partially obscures the DM in lateral view. A ventrolateral ala terminates in a blunt spine and has a thick leading edge that carries forward as a curved rib and crosses a swelling at about third length. Central part of valve surface is coarsely reticulate and crossed by a longitudinal median rib that runs from in front of the eye-spot to about two-thirds valve length.

Internal features. MA wide, though not seen clearly. MS not seen. Hinge in LV consists of a long, straight crenulate ME bar, which thickens at its anterior end and possibly at its posterior end. There is an ATE socket, but PTE socket not observed.

Remarks

H. challengeri differs from the type species and from *H. ewingenis* in having a relatively subdued ventrolateral swelling and a symmetrically pointed PM. It is closely related to *H. ewingensis*, but differs further in aspects of ornamentation by possessing a longitudinal median rib and anteriorly projecting ribs from both the posterior CA and ala. In *H. challengeri* the line of greatest length is closer to mid-height.

Damotte (1979) recorded specimens identified as *Paranotacythere* sp. 69 from the Aptian (Foraminifera zone MC 22) of DSDP 400A in the northern Bay of Biscay. Her illustrations (plate 1 (figs 6–7)) bear a considerable resemblance to *H. challengeri*, which, taken in conjunction with the doubtful generic assignment for her material (no internal views), suggests that the North Atlantic species may also belong to *Hemiparacytheridea*.

Dimensions (mm)

	length	height
6058	0,28	0,15

Age and distribution

H. challengeri is known only from the early–middle Albian of DSDP 330 (core 1/cc) on the Falkland Plateau.

Genus *Pedicythere* Eagar, 1965

Pedicythere falklandensis sp. nov.

Fig. 17B

Derivation of name

Falkland Plateau, site of DSDP boreholes from which type specimens were obtained.

Holotype

SAM–PC6059, LV, DSDP 330, core 1/cc, early–middle Albian.

Paratype

SAM–PC6060, LV, DSDP 330, core 1–1/112–116 cm, early–middle Albian.

Diagnosis

Species with drawn-out posterior area and pointed PM. Greatest length lies along DM.

Description

External features. AM broadly rounded, separated from DM by a small step. PM drawn out, highly asymmetric, apex in line with DM, slightly upturned dorsally, posteroventral part of PM slopes up strongly, and bears a broad spine. DM straight and coincides with line of greatest length. VM broadly convex, partially obscured in lateral view by ala. Ventrolateral area bears a large hollow spine that projects almost at right angles to valve surface. This spine has a short leading-edge ridge. Anterior area compressed and separated from rest of valve by a low ridge running in a curved line from the anterodorsal margin step to the ventral surface under the ala. DM margin obscured by a delicate frieze-like rim.

Internal features. Poorly seen. In LV hinge ME consists of a long, slightly sinuous narrow bar, PTE is a narrow crenulate socket, ATE is a rounded ?smooth hollow. MS and MA not seen clearly.

Remarks

P. falklandensis is closest to *P. fragilis* Dingle, 1981, from the Maastrichtian of Zululand, but differs in having a more acuminate posterior area, a less posteriorly deflected ala, and lacking the ala leading-edge extension to the AM.

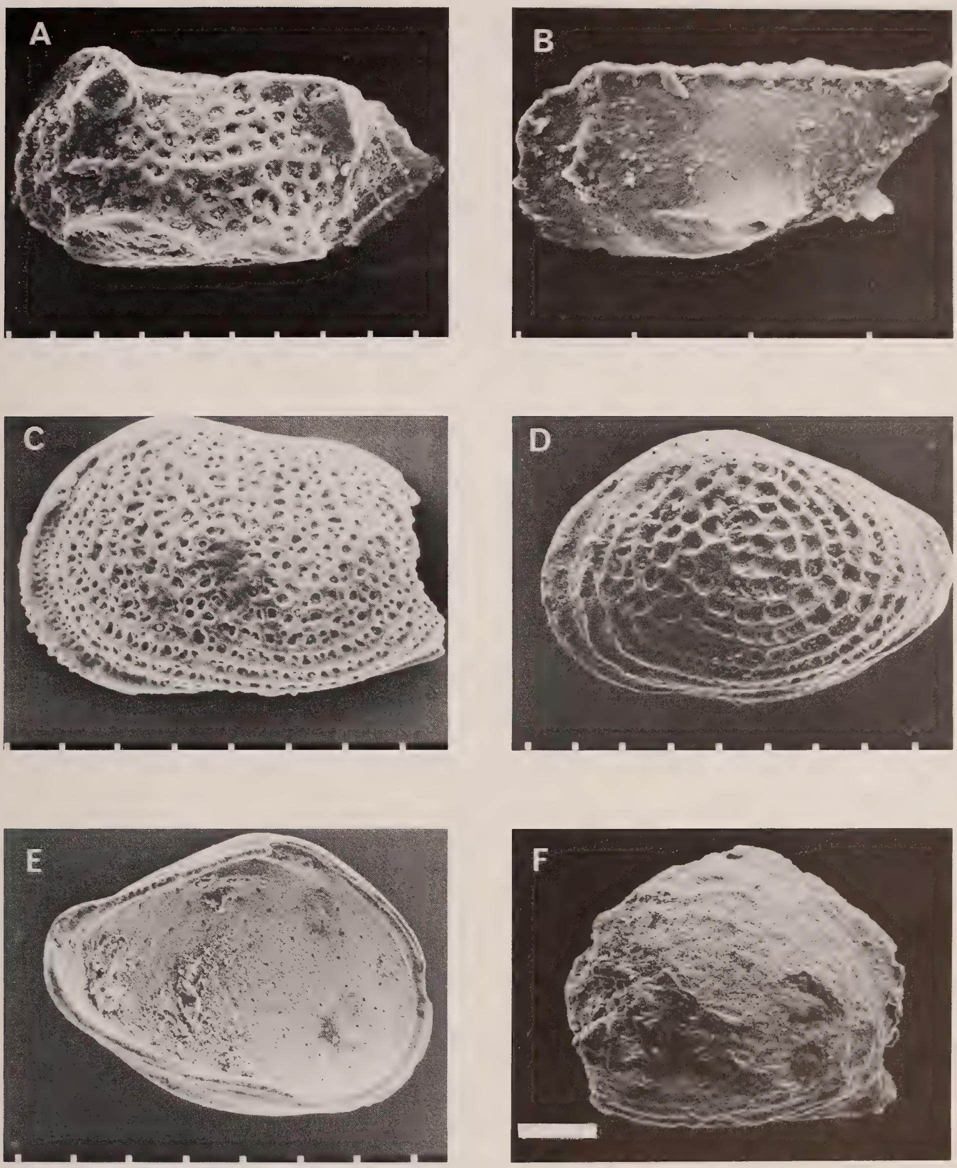


Fig. 17. A. *Hemiparacytheridea challengeri* sp. nov., holotype, SAM–PC6058, LV, DSDP 330, core 1–1/112–116 cm, early–middle Albian. B. *Pedicythere falklandensis* sp. nov., holotype, SAM–PC6059, LV, DSDP 330, core 1/cc, early–middle Albian. C. *Majungaella* cf. *M. queenslandensis* Krömmelbein, 1975, LV, TBD 1113, Middle–Upper Albian. Originally illustrated by Dingle (1971, fig. 4) and designated MG–3–1–9, this specimen was destroyed during SEM preparation. D–E. *Majungaella nematis* Grekoff, 1963, locality 171–1, Mlambongwenya Spruit, Zululand, Aptian IV. D. SAM–PC6061, LV. E. SAM–PC6062, LV, internal view. F. *Majungaella ?hemigymnae* Brenner & Oertli, 1976, SAM–PC6063, LV of carapace, locality 152–5, Mkuze, Zululand, Aptian IV.

Scale bars: A = 30 μ, others = 100 μ.

P. australis Neale, 1975, from the Santonian of western Australia has different PM and AM outlines, and has a ventrally directed ala spine.

Dimensions (mm)

	length	height
6059	0,32	0,17
6060	0,38	0,22

Age and distribution

P. falklandensis is known only from the early–middle Albian at DSDP site 330 (core 1/cc and 1–1/112–116 cm), where it is rare (*c.* 1% total ostracod population).

Family **Progonocytheridae** Sylvester-Bradley, 1948

Subfamily Progonocytherinae Sylvester-Bradley, 1948

Genus *Majungaella* Grekoff, 1963

This taxon is one of the characteristic elements of the South Gondwana Upper Jurassic to mid-Cretaceous ostracod province, extending from Argentina via the Falkland Plateau, South and east Africa, and India, to Australia.

Majungaella cf. *M. queenslandensis* Krömmelbein, 1975

Figs 17C, 18

Majungaella sp. A Dingle, 1971: 400–401; fig. 4.

Remarks

Originally compared to *M.* cf. *nematis* by Dingle (1971), this species is probably closer to *M. queenslandensis* on the basis of its finer reticulation pattern, and small anterodorsal marginal spines. Its MS pattern consists of four

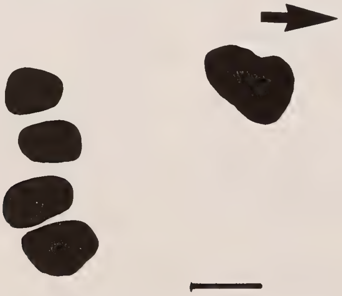


Fig. 18. Muscle scars of *Majungaella* cf. *M. queenslandensis*, TBD 1113, Agulhas Bank, Middle–Upper Albian. MG-3-1-9 of Dingle (1971, fig. 4) and Figure 17C (this paper). Scale bar = 30 μ.

rounded adductors and a rounded anterior scar (Fig. 18). During SEM preparation, the only good specimen (illustrated by Dingle, 1971, MG-3-1-9) was unfortunately crushed. The specimens illustrated by Krömmelbein (1975) have a slightly coarser reticulation than the Agulhas Bank material.

Age and distribution

M. cf. *queenslandensis* is known only from samples TBD 1113 and 1266 from the Alphard Formation of the Agulhas Bank, which have been dated as Middle–Upper Albian and Upper Aptian–Albian, respectively (see *Introduction*). *M. queenslandensis* was recorded by Krömmelbein (1975) from the Albian–Cenomanian Allaru Mudstone of the Great Artesian Basin, south-western Queensland, Australia.

Majungaella nematis Grekoff, 1963

Fig. 17D–E

Majungaella nematis Grekoff, 1963: 1744: pl. 5 (fig. 141–145), pl. 9 (figs 213–232). Sigal, 1974: pl. 1 fig. 4a–b. Brenner & Oertli, 1976: 501–502, pl. 5 (fig. 11–12). McLachlan *et al.*, 1976*b*: 346, fig. 15 (14–15). Guha 1976: 87, pl. 3 (fig. 23a–c).
Neocythere (N.) uitenhagensis Dingle, 1969: 152–153, fig. 11, pl. 9a–c.
Novocythere santacruziana Rossi de Garcia, 1972: in Malumian *et al.*: 271, pl. 1(7).

Remarks

Specimens of *M. nematis* from Zululand show no significant morphological differences to material from the Algoa–Outeniqua basins in the southern Cape or from other Gondwanide localities, indicating that this species exhibited intraspecific stability over its wide geographical and time ranges.

Age and distribution

M. nematis is known to have the following distributions in time and space:

1. Portlandian to Valanginian in the Majunga Basin of Madagascar (Grekoff 1963).
2. Upper Valanginian to Hauterivian, Lower Sundays River Formation, Outeniqua–Algoa basins (Dingle 1969; Brenner & Oertli 1976; McLachlan *et al.* 1976*b*).
3. ?Portlandian, Brenton Beds, Knysna–Outeniqua Basin (McLachlan *et al.* 1976*b*).
4. ?Hauterivian to Barremian in Santa Cruz Province, Argentina (Malumian *et al.* 1972).
5. Aptian IV to Cenomanian II, Makatini and Mzinene formations in the Mkuze, Mlambongwenya Spruit, and Ndumu areas of Zululand.
6. Early Cretaceous (860–755 m) of the Banni borehole, Rann of Kutch, India (Guha 1976).
7. 'Neocomian', DSDP site 249 (Mozambique Ridge) (core 27–3/26 cm) (Sigal 1974).

This list suggests that *M. nematis* was widely distributed in southern Gondwana during mid-Mesozoic times (Argentina to India), while its total temporal range was Portlandian to Cenomanian II. This is also its time range in southern Africa.

In Zululand *M. nematis* forms only a minor element of the ostracod faunas, but in the Algoa Basin it reached 7 per cent of the total population (Dingle 1982), and Grekoff (1963) notes that in the Majunga Basin of Madagascar it is 'common' and 'rare' in the Portlandian and Valanginian, respectively.

Majungaella ?hemigymnae Brenner & Oertli, 1976

Fig. 17F

Majungaella hemigymnae Brenner & Oertli, 1976: 504–505, pl. 6 (fig. 1–4), pl. 8 (fig. 5). McLachlan *et al.*, 1976*b*: 364, fig. 15 (17).

Remarks

A fragmentary carapace with longitudinal ribbing confined to the ventral part of the lateral surface. Outline and ornamentation very similar to Brenner & Oertli's species, but comparison of critical posterior areas not possible.

Age and distribution

Known only from the Makatini Formation (Aptian IV) at Mkuze, Zululand (locality 152–7). *M. hemingymnae* has been reported from the Lower Sundays River Formation of the Algoa Basin (Hauterivian) (Brenner & Oertli 1976), and from the Lower Sundays River and Kirkwood formations (?Berriasian to Valanginian) of the Outeniqua Basin and Brenton Beds (?Portlandian to Berriasian) at Knysna (McLachlan *et al.* 1976*b*).

Majungaella? sp. 327/16

Fig. 19A–C

Remarks

One LV of a progonocytherid with *Majungaella*-like aspect. Differs from previously described species of this genus in being more acuminate posteriorly, and having wider MA. The hinge appears to be antimerodont, with a large accommodation groove, but is poorly preserved. MS well seen: consist of a V-shaped frontal scar and four oval posterior scars in a vertical row.

Age and distribution

Recorded from middle Albian at DSDP site 327 (core 16–6/126–130 cm) on the Falkland Plateau.

Genus ***Pongolacythere*** gen. nov.

Derivation of name

Pongola, river valley location of holotype, plus generic appellation *cythere*.

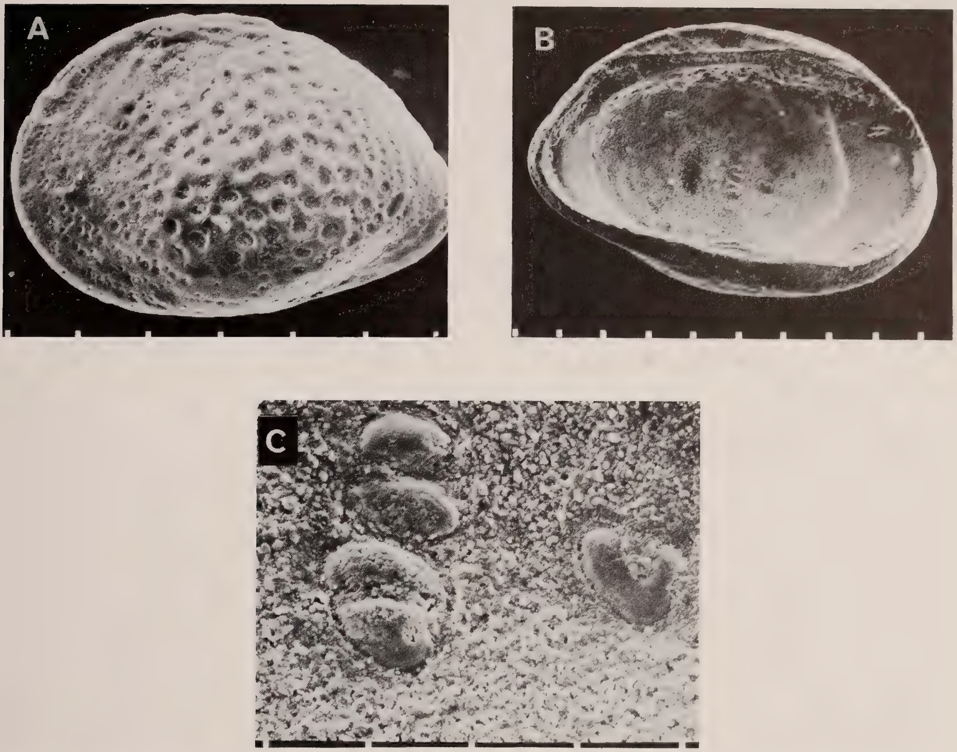


Fig. 19. A–C. *Majungaella?* sp. 327/16, SAM–PC6064, LV, DSDP 327, core 16–6/126–130 cm, middle Albian. A. Lateral view. B. Internal view. C. Muscle scars.
Scale bars: A–B = 100μ, C = 30μ.

Type species

Pongolacythere striata sp. nov.

Diagnosis

Progonocytherid with an elongate carapace, round AM and PM. Hinge paramphidont. MA anteriorly narrow with about ten short RPC. MS probably consist of V-shaped anterior scar and curved row of four adductors. Lacks eyespots, SCT, and prominent longitudinal ridges.

Remarks

Although the hinge structure, lack of prominent longitudinal ridges, eyespots and SCT suggest an assignment to the Progonocytheridae, the overall shape of this new genus is not typical of the subfamily, and the placement must be considered provisional.

Pongolacythere has similarities to several genera, but differs from them on various points: *Acanthocythere* Sylvester-Bradley, 1948 (Bathonian of England) has eye-spots and a lobodont hinge; *Posteroprotocythere* Mandelstam, 1958 (Lower Jurassic to Upper Cretaceous of western and south-eastern Europe and south-western Asia) has an entomodont hinge and an outline reminiscent of *Protocythere*; and *Mosaeleberis* Deroo, 1966 (Upper Cretaceous to Lower Tertiary of Europe) has an SCT, prominent longitudinal ridges and numerous (about thirty) anterior RPC. As far as African localities are concerned, it bears some resemblance to *Mandwacythere* Bate, 1975 (Portlandian of Tanzania), but this genus has a lophodont hinge and anterior vestibules. Bate (in Bate & Bayliss 1969) records four specimens of an apparently blind elongate species with fine longitudinal lateral ribs (Genus A from the Albian of Tanzania). He does not give an additional description, but from his illustration (pl. 5 (fig. 16)), this species could well belong within the genus *Pongolacythere*.

Age and distribution

So far known only from the Aptian IV to Albian III of northern Zululand, but may occur in the Albian of Tanzania (as Genus A of Bate, in Bate & Bayliss 1969).

Pongolacythere striata sp. nov.

Figs 20A–E, 21

Derivation of name

Latin *striatus* (fine line): reference to surface ornamentation of fine ribbing.

Holotype

SAM–PC6065, RV, locality 171–1, Makatini Formation, Mlambongwenya Spruit, Aptian IV.

Paratypes

SAM–PC6066, LV, as above.
SAM–PC6067, RV, as above.

Diagnosis

Species with ornamentation of fine longitudinal ribbing and reticulation, with foveolate intercostal areas.

Description

External features. Elongate, with RV AM asymmetrically rounded. LV AM broadly rounded and more symmetrical. PM rounded, slightly tapering. DM and VM almost straight and parallel; DM in LV has rounded elevation over CA. Surface ornamented with numerous fine longitudinal ribs converging somewhat towards anterior end. Posterior area is delicately reticulate. Intercostal areas have fine foveolate ornamentation. There is no SCT.

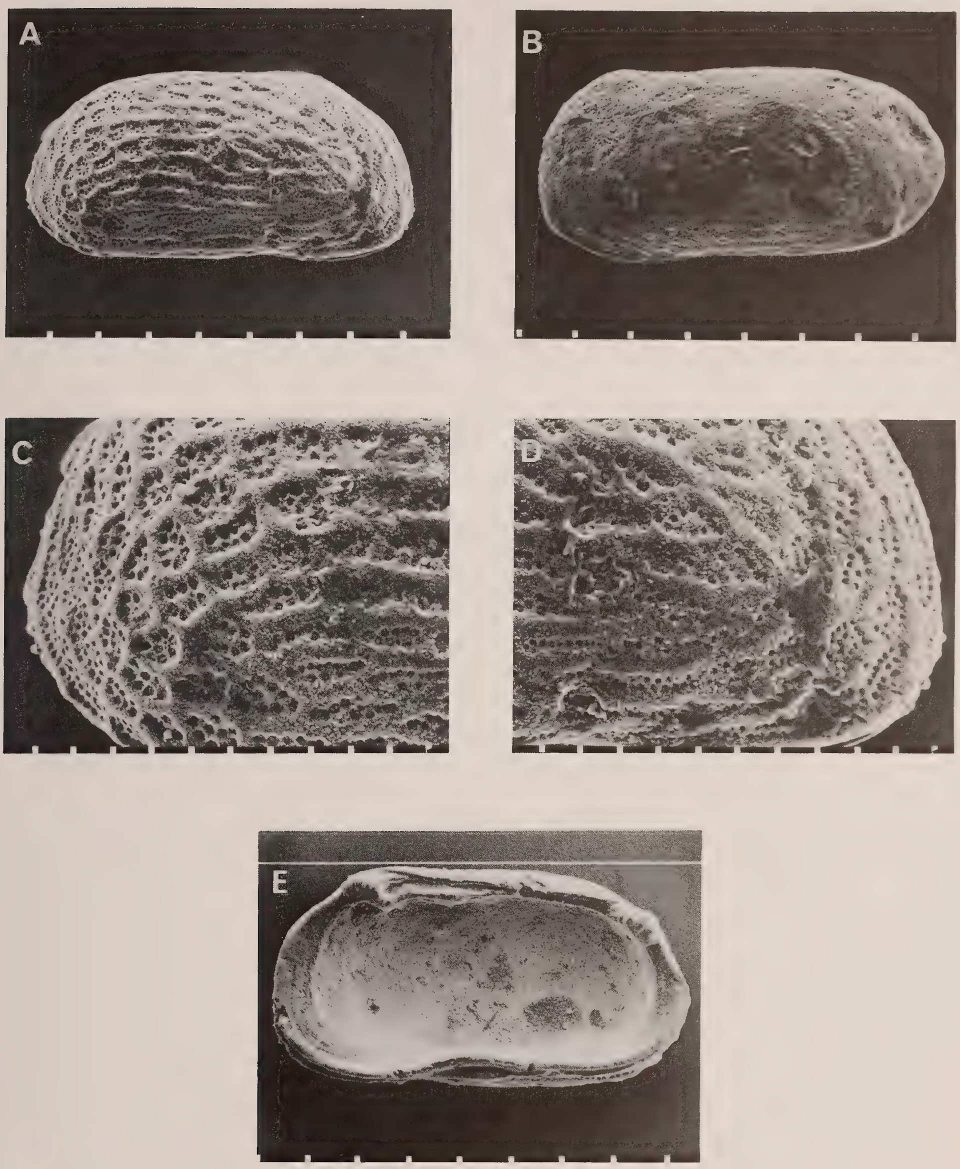


Fig. 20. A–E. *Pongolacythere striata* gen. et sp. nov., locality 171–1, Mlambongwenya Spruit, Zululand, Aptian IV. A, C–E. Holotype, SAM–PC6065, RV. A. External lateral view. C. Detail posterior area. D. Detail anterior area. E. Interior view. B. SAM–PC6066, LV. Scale bars: A–B, E = 100μ, C–D = 30μ.

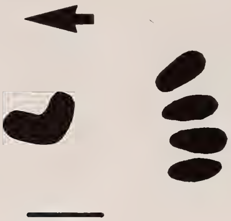


Fig. 21. Muscle scars of *Pongolacythere striata* gen. et sp. nov., SAM–PC6067, LV, locality 171–1, Mlambongwenya Spruit, Zululand, Aptian IV. Scale bar = 30 μ.

Internal features. MA moderately wide, few (*c*. 10) straight, simple RPC anteriorly. Hinge paramphidont: in RV ATE consists of a large denticulate process, PTE a similar feature, which is highest posteriorly. ME smooth: consists of a long, narrow groove and a small, rounded anterior peg. No unworn LV hinges seen. MS not well preserved, apparently consist of a V-shaped anterior scar (may be subdivided and accompanied by two further scars dorsally), and four elliptical adductors in a curved row.

Remarks

Externally *P. striata* bears some resemblance to *Mosaeleberis interrupta* (Bosquet 1847) (Maastrichtian, western Europe), the type species of *Mosaeleberis* Deroo, 1966, but differs in lacking a prominent median longitudinal rib and an SCT. In addition, the DM and VM of *M. interrupta* converge posteriorly. *Mandwacythere striata* Bate, 1975 (Upper Jurassic, Tanzania) has a similar shape and ornamentation, but differs in the structure of its hinge and MA.

Dimensions (mm)

	length	height
6065	0,75	0,38
6066	0,72	0,34
6067	0,76	0,35

Age and distribution

This species is known to range Aptian IV to Albian III in the Mkuze and Mlambongwenya areas of northern Zululand.

Subfamily Protocytherinae Lubimova, 1955

Genus *Arculicythere* Grekoff, 1963

This is another taxon of the family Progonocytheridae that is typical of the Lower to mid-Cretaceous of the South Gondwana ostracod province. It has been recorded from the Falkland Plateau, Agulhas Bank, Madagascar, and off north-western Australia, and although Grekoff (1963) recorded it ranging Portlandian to Valanginian in Madagascar, it appears to be most abundant in the Albian of the Falkland Plateau, Agulhas Bank, and north-western Australia. Swain (1976) tentatively identified two valves as *Arculicythere?* sp. from the late Aptian–early Cenomanian of DSDP site 144 (core 5–1/3–9 cm) (north-west of Cape Verde Islands), but his illustrations are not typical of the genus, and probably do not belong to it. No unequivocal records of *Arculicythere* therefore exist outside the south Gondwanide oceans.

Arculicythere tumida Dingle, 1971

Figs 22A–F, 23A–D

Arculicythere tumida Dingle, 1971: 401–403, fig. 5.
Arculicythere? sp. A Oertli, 1974: 947, pl. 4 (figs 1–11), pl. 5 (figs 1–12).

Remarks

In the original diagnosis, Dingle (1971) mentioned an amphidont hinge. This was a typographical error, and in the accompanying description, it was correctly stated as antimerodont. SEM pictures of topotypes are included herein to supplement the original descriptions. Illustrations of material from the Falkland Plateau are indistinguishable from those of Agulhas Bank specimens. The specimens illustrated by Oertli (1974) from off-shore north-western Australia are somewhat more elongate, but otherwise fit well into the species.

The holotype and two paratypes of *A. tumida* originally designated MG–3–1–1, MG–3–1–2, and MG–3–1–3 respectively by Dingle (1971), have now been placed in the South African Museum under catalogue numbers SAM–PC–6068, 6069, and 6070 respectively. Figure 24 shows a length–height scattergram.

Age and distribution

A. tumida is known to have the following ranges and distribution:

1. Sample TBD 1113, Alphard Formation, Agulhas Bank (Middle–Upper Albian) (Dingle 1971).
2. Early to late Albian (cores 21–4/130–134 cm to 15–2/132–136 cm) at DSDP site 327, and early–middle Albian (cores 2–2/122–126 cm to 1–1/112–116 cm) at DSDP site 330, Falkland Plateau.
3. Middle–Upper Albian (cores 17–2/21–23 cm to 12–2/60–62 cm) DSDP site 259, north-west of Perth, western Australia (Oertli 1974).

This suggests that *A. tumida* was widely distributed in the proto south-eastern Atlantic and southern Indian oceans in ?early to late Albian times. An interesting aspect of its distribution in these three areas is that it typically forms a major element of the total ostracod population: Agulhas Bank (46%); Falkland Plateau (typically between 22% and 38%); and western Australia (63% of all Albian ostracods recorded at site 259), where it is locally the sole species. In

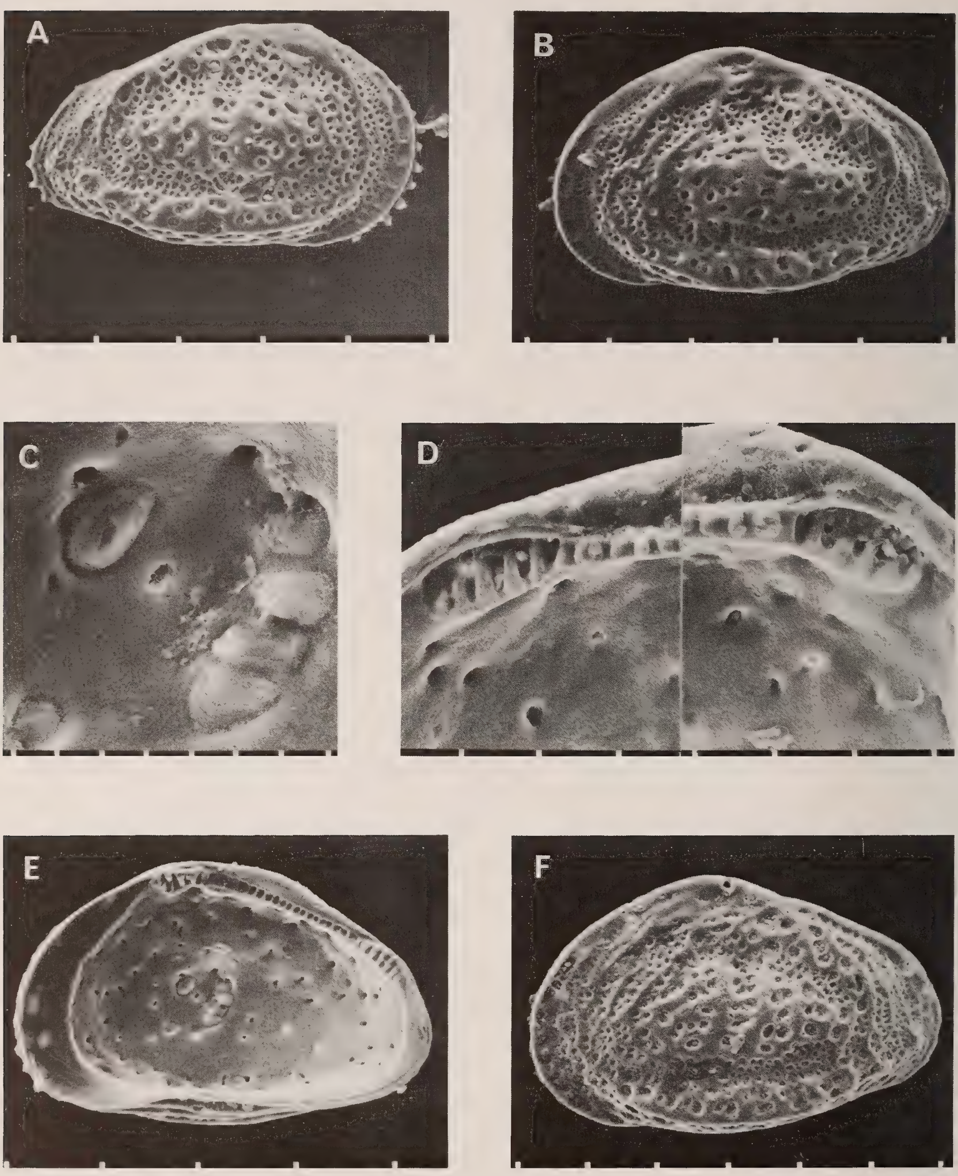


Fig. 22. A–F. *Arculicythere tumida* Dingle, 1971. A–E. TBD 1113, Agulhas Bank, Middle–Upper Albian. A. SAM–PC6071, RV. B. SAM–PC6072, LV. C, E. SAM–PC6073, RV. C. Muscle scars. E. Interior view. D. SAM–PC6129, LV. Details of ATE and PTE of hinge—composite photograph, whole of ME not shown. F. SAM–PC6074, LV, DSDP 330 core 1/cc, early–middle Albian.

Scale bars: A–B, E–F = 100μ, C = 10μ, D = 30μ.

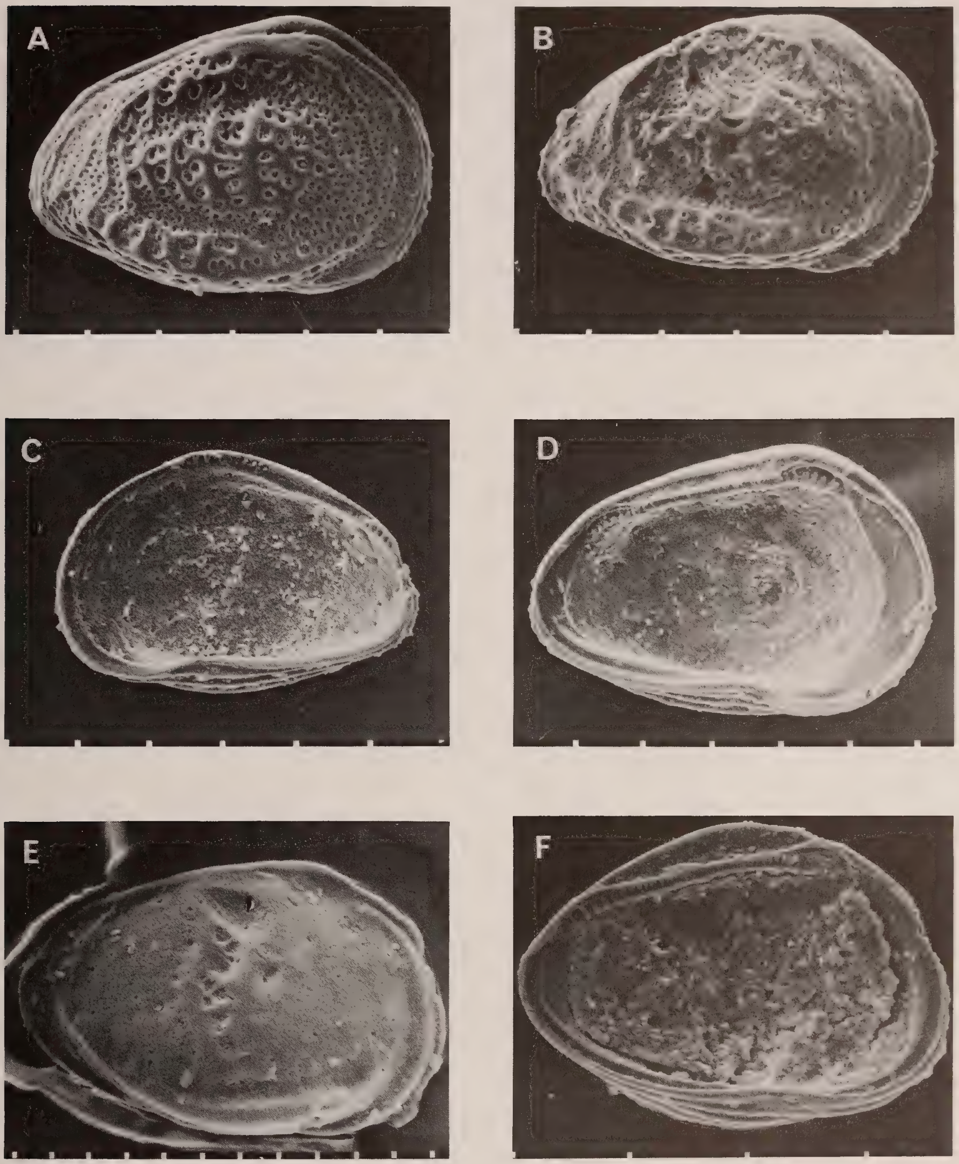


Fig. 23. A–D. *Arculicythere tumida* Dingle, 1971. A, C–D. DSDP 330, core 1/cc, early–middle Albian. A. SAM–PC6075, RV. C. SAM–PC6077, RV, internal view. D. SAM–PC6078, LV, internal view. B. SAM–PC6076, RV, DSDP 327, core 15–2/132–136 cm, late Albian. E–F. *Collisarboris? stanleyensis* sp. nov., DSDP 327, core 15–2/132–136 cm, late Albian. E. Holotype, SAM–PC6079, RV. F. SAM–PC6080, LV, internal view.

Scale bars: A–D, F = 100μ, E = 30μ.

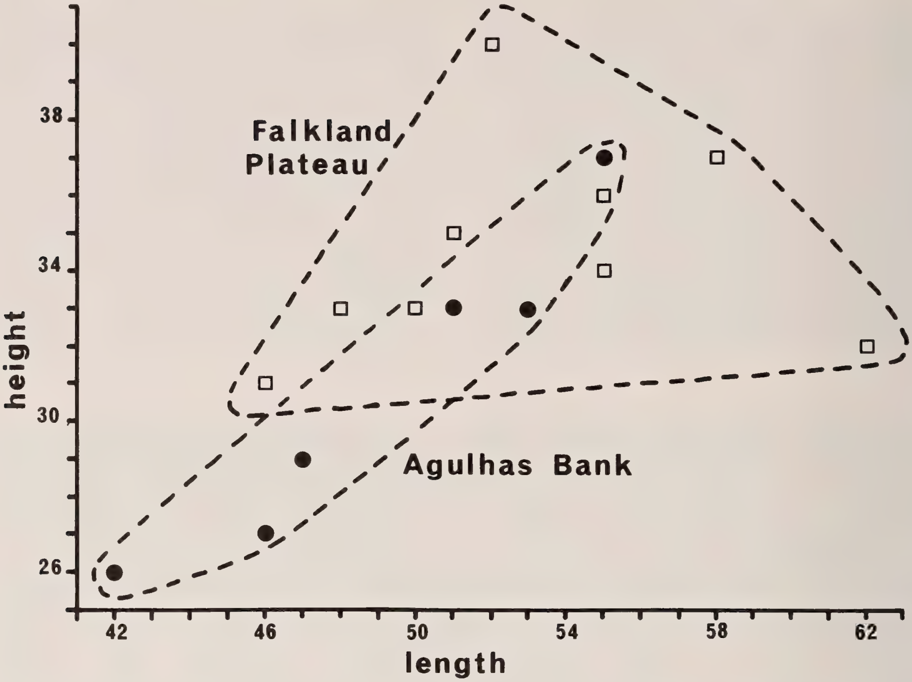


Fig. 24. Scattergram of length v. height for adult specimens of *Arculicythere tumida* from the Agulhas Bank (dots) and Falkland Plateau (squares) (scale ×10 μ).

addition, both the DSDP localities probably represent deposition in water depths between 100 and 200 m, and we suspect that this may also have been the case on the Agulhas Bank (see *Discussion*).

Family **Collisarborisidae** Neale, 1975

Genus *Collisarboris* Neale, 1975

Collisarboris? stanleyensis sp. nov.

Figs 23E–F, 25, 26A

Derivation of name

Port Stanley, capital of the Falkland Islands.

Holotype

SAM–PC6079, RV, DSDP 327, core 15–2/132–136 cm, late Albian.

Paratypes

SAM–PC6080, LV, as above.
SAM–PC6081, RV, as above.

Diagnosis

Blind species, with compressed AM area and prominent pits over MS on valve exterior.

Description

External features. Ovate outline, symmetrical, broadly rounded AM with narrow frilled border and low AM rim. Anterior part of valve compressed. PM roundly acuminate, apex at about mid-height. DM straight in RV, convex in LV. VM slightly convex, but hidden in lateral view by broad ventral overhang. Anterior CA fairly prominent in RV, with a depression below it. Lateral surface mostly smooth, but there are a few scattered large puncta and numerous fine puncta, and in the vicinity of a slight median sulcus the valve surface is often weakly and coarsely reticulate. MS pattern shows through in this sulcus as a line of pits. The wide ventral overhang has a broad keel along its outer edge.

Internal features. Hinge antimerodont: in RV the TE have large denticles, and the ME has finer crenulation; LV has a narrow accommodation groove and a prominently overhanging ledge, RV has a high concave elevation that receives the RV ledge. MA not clearly seen, nor MS from the inside, but external impressions indicate a long curved row of five posterior scars of which P2–P4 are partially subdivided, and a group of three smaller, rounded anterior scars (Fig. 25).

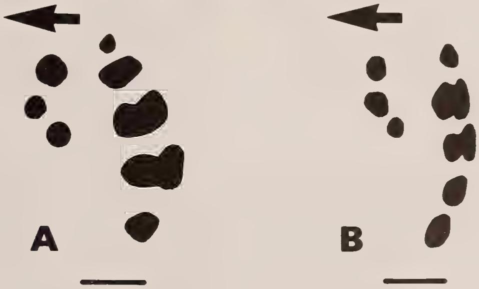


Fig. 25. Muscle scars of *Collisarboris? stanleyensis* sp. nov. A. DSDP 327, core 15–2/132–136 cm, late Albian. B. DSDP 327, core 16–4/66–70 cm, middle Albian.
Scale bars = 30 μ.

Remarks

Several aspects of *C? stanleyensis* do not fit precisely within Neale's (1975) original concept of the genus *Collisarboris* but, because it was based on one species, some extension may be considered permissible. The new species is blind, whereas the genotype *C. cooki* has small eye-spots and, while the hinges of *C? stanleyensis* and *C. cooki* are both characterized by accommodation grooves and shelves, it is the LV in the former and the RV in the latter that are the more imposing structures. The MS pattern in the Falkland Plateau species has five posterior scars compared to the four reported by Neale (1975), but the MS were obviously not well preserved in Neale's material because he could not see the frontal scars. Despite these differences, our specimens have the ovate, neocytherid shape, an antimerodont hinge, a carinate ala, and a smooth to punctate shell surface. Rather than erect a new higher taxon, it is felt that these similarities warrant tentative assignment to Neale's genus.

Dimensions (mm)

	length	height
6079	0,33	0,22
6080	0,36	0,26
6081	0,41	0,26

Age and distribution

C? stanleyensis is a rare to tertiary component of the middle (3%) to late Albian (6%) strata at two levels in DSDP 327 (cores 16–4/66–70 cm, and 15–2/132–136 cm) on the Falkland Plateau.

Genus *Sphaeroleberis* Deroo, 1966

Sphaeroleberis? sp. A

Fig. 26B

Remarks

One carapace and two valves of a species tentatively placed in *Sphaeroleberis*. Lack of good hinge views precludes a more definite assignment. In Europe the genus is typical of the Maastrichtian, and Neale (1977) has reassigned North American Campanian species to it. Bate (in Bate & Bayliss 1969) records *Sphaeroleberis africana* from the Turonian of Tanzania, and notes that Apostolescu (1963) described two species (*S. gambiensis* and *S. senegalensis*) from the Senonian of west Africa.

Our specimens are fairly close to *S. africana* but differ in PM outline, which is less acuminate and more upturned. In this respect, they also differ from *Neocythere (Centrocythere) denticulata* Mertens, 1956, from the Upper Aptian to Upper Albian of western Europe.

Age and distribution

This species ranges Albian III to Albian VI in the Mzinene Formation of the Mkuze and Ndumu areas of northern Zululand.

Family **Schizocytheridae** Mandelstam, 1959

Genus *Sondagella* Dingle, 1969

This is a further taxon that is typical of the uppermost Jurassic to mid-Cretaceous of the western part of the South Gondwana ostracod province (Argentina, Agulhas Bank and Mozambique Ridge).

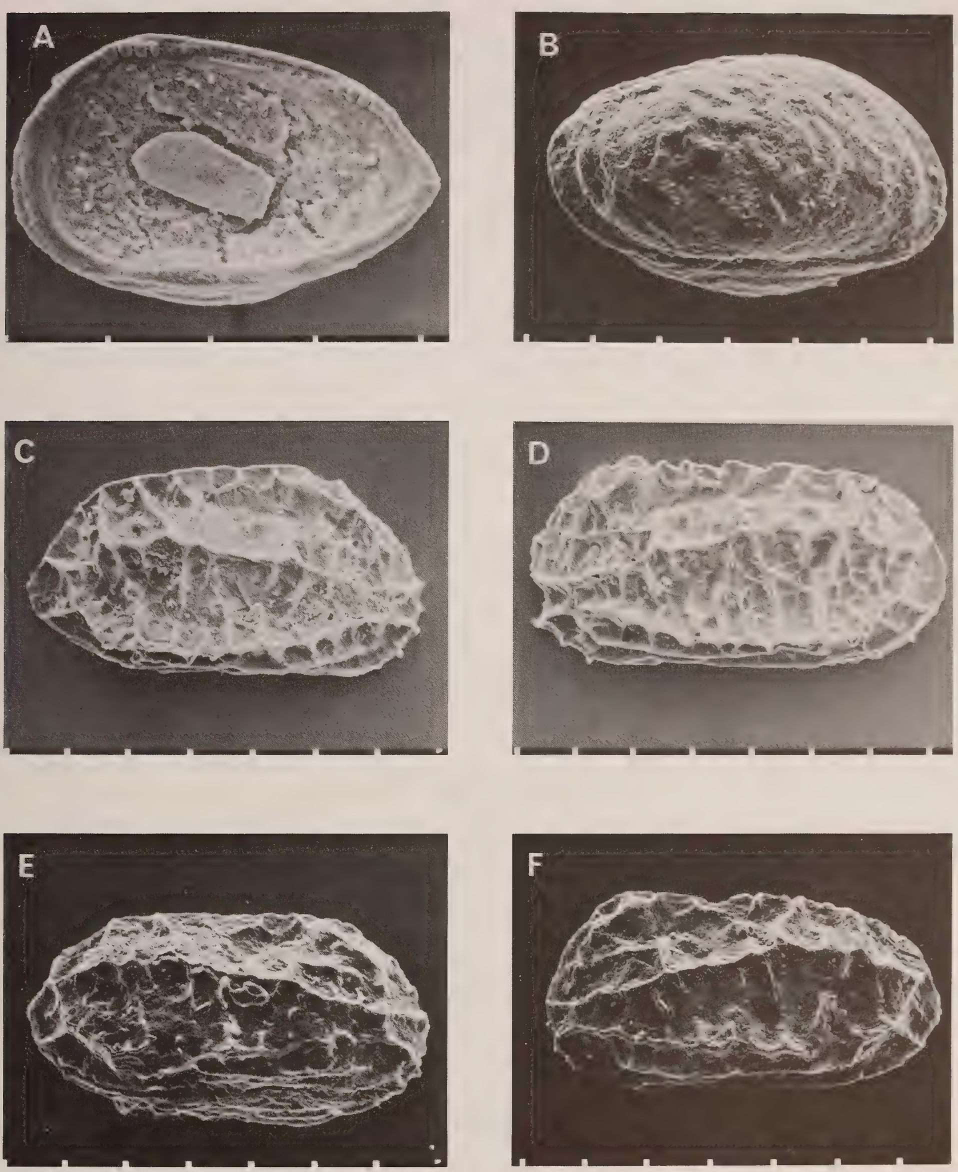


Fig. 26. A. *Collisarboris? stanleyensis*, SAM–PC6081, RV, DSDP 327, core 15–2/132–136 cm, late Albian. B. *Sphaeroleberis?* sp. A, SAM–PC6082, LV of carapace, locality 153, Mkuze, Zululand, Albian III. C–F. *Sondagella theloides* Dingle, 1969. C–D. TBD 1113, Agulhas Bank, Middle–Upper Albian. These two specimens are part of the population identified by Dingle (1971) as *Amphicytherura (Sondagella) theloides acuta*. C. SAM–PC6083, RV. D. SAM–PC6084, LV. E–F. Locality 153, Mkuze, Zululand, Albian III. E. SAM–PC6085, RV. F. SAM–PC6086, LV.
Scale bars = 100 μ.

Sondagella theloides Dingle, 1969

Fig. 26C–F

Amphicytherura (Sondagella) theloides Dingle, 1969: 157–161, fig. 13, pl. 9g–i. Brenner & Oertli, 1976: 496–497, pl. 4 (figs 13–16). McLachlan *et al.* 1976*b*: 363–364, fig. 15 (3–4). Musacchio, 1978: 464, pl. 1 (figs 21–23).
Amphicytherura (Sondagella) cf. *theloides* Dingle: Sigal, 1974: pl. 1 (fig. 6a–b).
Amphicytherura (S.) theloides acuta Dingle, 1971: 405–406, fig. 8.

Remarks

In view of the different lateral outline of *S. theloides* and *Amphicytherura dubia* Israelsky, 1929, Bate (1972) is followed here in raising *Sondagella* to generic status. The specimens of *S. theloides* from Zululand are very close to those from the southern Cape, but do seem to have a consistently less strongly curved anterior part to the longitudinal median rib, and a somewhat coarser aspect to ornamentation overall. The latter may, in part, be due to the relatively poor state of preservation of the Zululand material and, in any case, these variations are no more than can be expected intraspecifically from different geographical areas.

Musacchio (1978, 1979) records the species from Argentina, along with two closely related forms, *S. lestai* and an unnamed species that he placed in *?Acrocythere* sp. 2. He also recognized a variant of *S. theloides* that was described under *A. (S.) theloides* Form A (Musacchio 1978).

Age and distribution

S. theloides is known to have the following ranges and distribution:

1. Early Hauterivian in the Neuquen Basin of Argentina (Musacchio 1978).
2. Upper Valanginian to Lower Hauterivian, Lower Sundays River Formation, Algoa Basin (Dingle 1969; Brenner & Oertli 1976); Outeniqua Basin (McLachlan *et al.* 1976*b*).
3. ?Portlandian, Brenton Beds, Knysna (McLachlan *et al.* 1976*b*).
4. Middle–Upper Albian (TBD 1113), ?Alphard Formation, Outeniqua Basin, Agulhas Bank (Dingle 1971).
5. Albian III, Mzinene Formation, Mkuze area, Zululand.
6. Early Aptian or Barremian, DSDP site 249, Mozambique Ridge (core 26–1/40 cm) (Sigal 1974).

This suggests that *S. theloides* was widely distributed along the southern edge of West Gondwana in early to mid-Cretaceous time (Neuquen Basin in the west to Mozambique Ridge in the east), although it was absent from the eastern Falkland Plateau. Its temporal range in south-east Africa was ?Portlandian to Albian III (possibly Upper Albian in the Outeniqua Basin). It was probably an environmentally tolerant species that inhabited both shallow, near-shore (Algoa Basin), and deeper shelf areas (*c.* 200 m, Agulhas Bank) (see *Discussion*).

Family **Trachyleberididae** Sylvester-Bradley, 1948

Subfamily Trachyleberidinae Sylvester-Bradley, 1948

On the Falkland Plateau, trachyleberid ostracods are represented by one species (*Isocythereis sealensis*), which is relatively abundant at site 327 (average 8% in 6 samples, with a maximum of 14% in core 17). Generally speaking, however, these localities are noted for their relative lack of members of this family. In Zululand, in contrast, trachyleberid taxa are represented by 3 species in 2 genera which constitute an average of 36% of the total ostracod fauna in the 6 fossiliferous levels investigated (range 9–84%). To emphasize the contrast between the two areas further, the Falkland Plateau trachyleberids form an average of 31% of the cytheracean population, while in Zululand this figure is 51%.

Genus *Isocythereis* Triebel, 1940

Isocythereis sealensis Dingle, 1971

Figs 27A–F, 28A–D

Isocythereis sealensis Dingle, 1971: 412–413, fig. 14.

Neotype

SAM–PC6087, sample TBD 1113, ?Alphard Formation, Agulhas Bank, Middle–Upper Albian.

During the course of the present investigation, the holotype of the species (MG–3–1–6), which was a fragile specimen, fragmented. Sample 1113 originally contained five specimens. Following the destruction of the holotype, the paratype (MG–3–1–6) (Dingle 1971) has been retained as such, and one of the three remaining specimens has been selected as the neotype and illustrated.

Dimensions (mm)

	length	height
6087	0,61	0,35

Remarks

In the original description, Dingle (1971) identified small rounded eyespots. Re-examination of the type material under SEM shows this to be incorrect, and the species is now known to have been blind. Twenty additional specimens have been recovered from DSDP sites on the Falkland Plateau, and these allow a more broadly based assessment of the species' characters to be made.

External features that should be stressed are the flared margin over the anterior CA LV, and the prominent, narrow AM rim (both valves). Although the delicate reticulate ornamentation found in the Agulhas Bank specimens is met with in the Falkland Plateau material, the latter's ornamentation tends to be coarser, with the valves more heavily calcified.

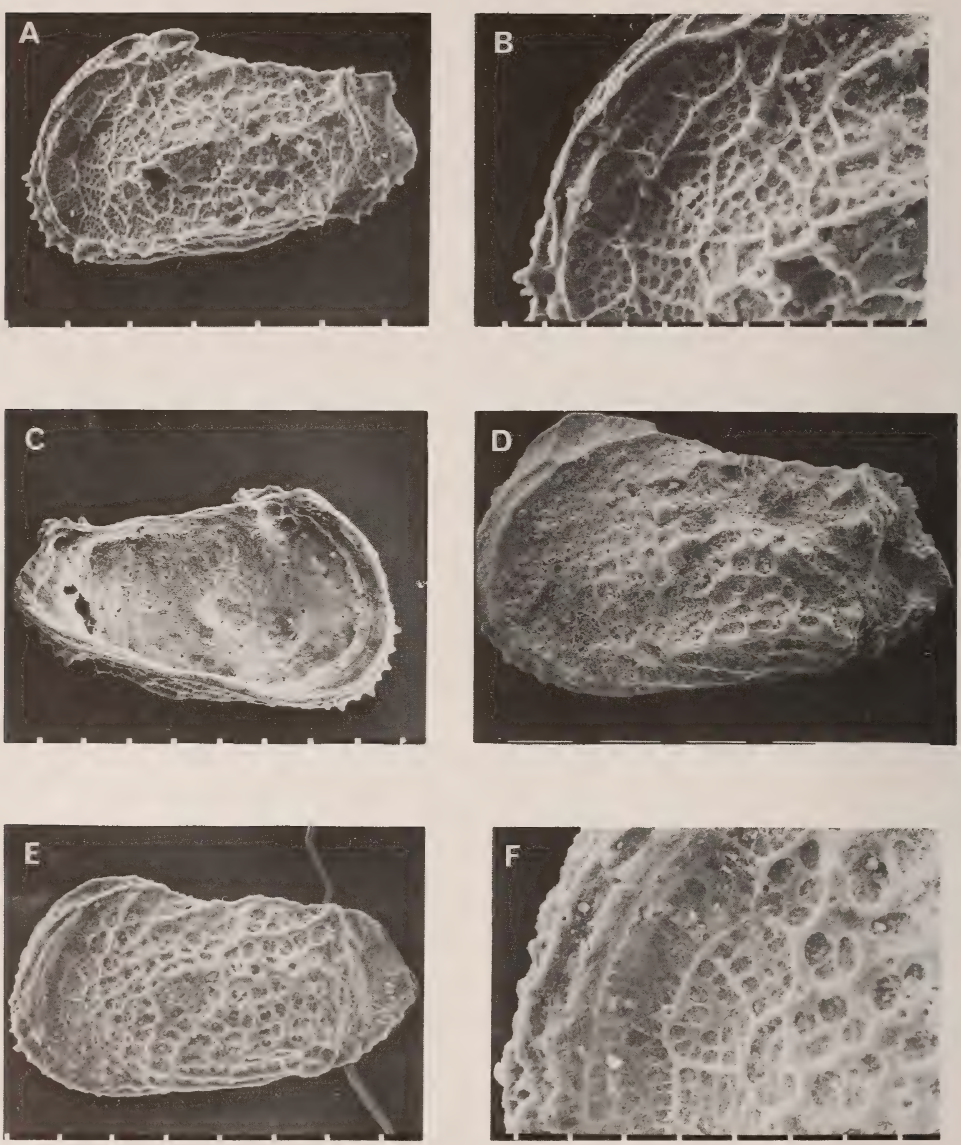


Fig. 27. A–F. *Isocythereis sealensis* Dingle, 1971. A–C. Neotype, SAM–PC6087, LV, TBD 1113, Agulhas Bank, Middle–Upper Albian. A. External lateral view. B. Detail anterior area. C. Internal view. D–F. DSDP 327. D. SAM–PC6088, LV, core 16–6/125–130 cm, middle Albian. E–F. SAM–PC6089, LV, core 15–2/132–136 cm, late Albian. E. External lateral view. F. Detail anterior area.
Scale bars: A, C–E = 100μ, B, F = 30μ.

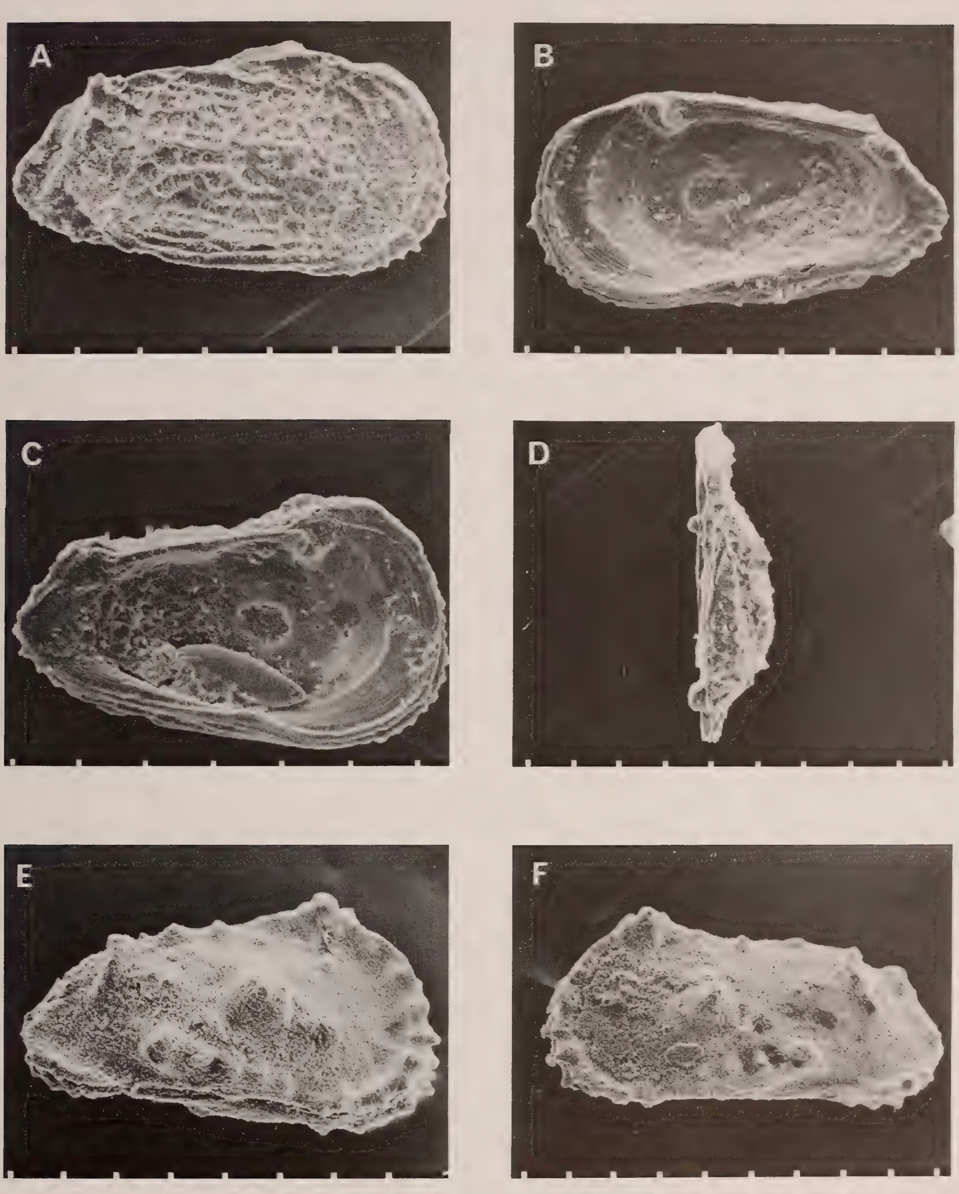


Fig. 28. A–D. *Isocythereis sealensis* Dingle, 1971. A. SAM–PC6090, RV, DSDP 330, core 1–1/112–110 cm, early–middle Albian. B. SAM–PC6092, RV, DSDP 327, core 16–6/125–130 cm, middle Albian. C. SAM–PC6093, LV, DSDP 327, core 15–2/132–136 cm, late Albian. D. SAM–PC6091, RV dorsal view, DSDP 327, core 18–6/106–110 cm, middle Albian. E–F. *Isocythereis? ndumuensis* sp. nov., locality Ndumu 3–1, Inyamathi Pan, Zululand, Cenomanian III. E. Holotype, SAM–PC6094, RV. F. SAM–PC6095, LV. Scale bars = 100μ.

Internally, it can now be established that while the hinge is hemiamphidont, the ATE RV is weakly subdivided and the PTE LV consists of a large socket that opens broadly into the valve interior and has a thick, humped exterior rim. ATE LV is also a rather broad structure, opening into the interior of the valve.

Bate (in Bate & Bayliss 1969) recorded *Isocythereis* sp. (British Museum Io 782) from the Turonian of Tanzania, but this species differs from *I. sealensis* in having large eye-spots, a prominent SCT, a thick AM rim, and bluntly spinose ornamentation on the dorso- and ventrolateral longitudinal ribs.

Age and distribution

In South Africa, *I. sealensis* is known only from sample TBD 1113 on the Agulhas Bank (Middle–Upper Albian). On the Falkland Plateau it ranges as follows: DSDP 330 early–middle Albian (core 1–1/112–116 cm); DSDP 327 middle to late Albian (cores 18–6/106–116 cm to 15–2/132–136 cm). It is never abundant, but at two levels (DSDP 327 core 17 and core 15) reaches 14% and 10% respectively, of the total ostracod population.

Isocythereis? ndumuensis sp. nov.

Figs 28E–F, 29A

Derivation of name

Locality of type specimens, Ndumu region of northern Zululand.

Holotype

SAM–PC6094, C, locality Ndumu 3–1, Inyamathi Pan, Mzinene Formation, Cenomanian III.

Paratypes

SAM–PC6095, C, as above.

SAM–PC6096, C, as above.

SAM–PC6097, C, locality 178, Msunduzi Pan, Ndumu, Mzinene Formation, Albian VI.

Diagnosis

Species with elongate triangular lateral outline, smooth to weakly reticulate intercostal areas, prominent turret-like eye-spot.

Description

External features. In lateral view elongate, asymmetrically rounded AM with short stout spines anteroventrally, DM and VM converge posteriorly, both are weakly concave. PM is triangular. Anterior and posterior CA prominent, with turret-like eye-spots in both RV and LV. Posteroventral margin weakly spinose. Surface ornamented with dorsal and ventral spinose ridges and lines of spines. The ventral ridge typically consists of 5 stout spines on a low elevation that rises posteriorly and is continuous with the well-developed spinose AM ridge. The dorsal lineation consists of four low spines on a weak ridge, and culminates posteriorly in a well-developed CA and a short low ridge that runs parallel to the posterior margin in LV, and almost at right angles to DM in RV. There is a prominent rounded SCT bearing stout spines. In RV there is also a small spine anteroadjacent to the SCT. Intercostal areas typically smooth, but Albian specimens have weak intercostal reticulation.

Internal features. None seen.

Remarks

Tentatively placed in *Isocythereis* on general external features. The new species is very similar to *Isocythereis* sp. (British Museum Io 782) from the Turonian of Tanzania (Bate & Bayliss 1969) but is overall less spinose. It differs from *I. sealensis* from the Agulhas Bank and the Falkland Plateau by possessing large eye-spots (*I. sealensis* is blind), and by lacking well-developed reticulate ornamentation. *Spinoleberis?* GA E 12 (Grosdidier 1979) from the Upper Cenomanian of Gabon has a similar ornamentation to *I? ndumuensis*, but is more elongate and apparently lacks a prominent eye-spot.

Dimensions (mm)

	length	height	width
6094	0,75	0,40	
6095	0,84	0,42	
6096	0,90		0,45
6097	0,84	0,38	

Age and distribution

I? ndumuensis is known to range Albian VI to Cenomanian III in the Ndumu region of Zululand.

Genus *Cythereis* Jones, 1849

Cythereis agulhasensis Dingle, 1971

Fig. 29B–D

Cythereis agulhasensis Dingle, 1971: 411–412, fig. 13.

Remarks

No further specimens of this distinctive species have been recovered, but SEM pictures are included here to amplify the original description. In particular, attention is drawn to the delicate recticulate and foveolate ornamentation at the posterior ends of the median and ventrolateral ridges, which contrasts with the otherwise overall smooth valve surface. The MS pattern is now shown to consist of four elongate adductors and a U-shaped anterior scar.

The holotype originally designated MG–5–1–2 by Dingle (1971) has now been placed in the South African Museum under catalogue number SAM–PC6098.

Age and distribution

Known only from sample TBD 1266, ?Alphard Formation on the Agulhas Bank (Upper Aptian–Albian).

Genus ***Makatinella*** gen. nov.

Derivation of name

Locality of holotype, Makatini Flats, Zululand.

Type species

Makatinella tritumida sp. nov.

Diagnosis

Trachyleberid with the following characters: asymmetrically rounded AM, large anterior hinge ears in LV and RV, prominent eye-spots, straight VM forming continuation with the ventrally deflected PM, prominent rounded SCT, three longitudinal ribs, fourteen to sixteen anterior RPC. Surface weakly reticulate to smooth with numerous pustules.

Remarks

Makatinella has some similarities with *Cornicythereis* Gründel, 1973 (which Damotte (1977) considers a subgenus of *Cythereis*) and *Costacythere* Gründel 1966, but differs from both in possessing a straight VM that is contiguous with the PM. *Rehacythereis* Gründel, 1973 (which Damotte (1977) also considers a subgenus of *Cythereis*) differs from *Makatinella* in lacking the prominent anterior hinge ears and well-defined median rib. Despite these differences, *Makatinella* is clearly related to these European *Cythereis*-like taxa, which have the following ranges: *Cornicythereis*—?Barremian to Albian (Gründel 1974); *Costacythereis*—Hauterivian to Barremian (Bartenstein & Oertli 1975); and *Rehacythereis*—?Valanginian to Palaeocene (Gründel 1974).

Cythereis itself has a centrally pointed PM and a symmetrically rounded AM.

Age and distribution

The two new species recognized in this study, *M. tritumida* and *M. inflata*, range Aptian IV to Cenomanian III and Aptian IV to Albian III respectively, and are known only from Zululand.

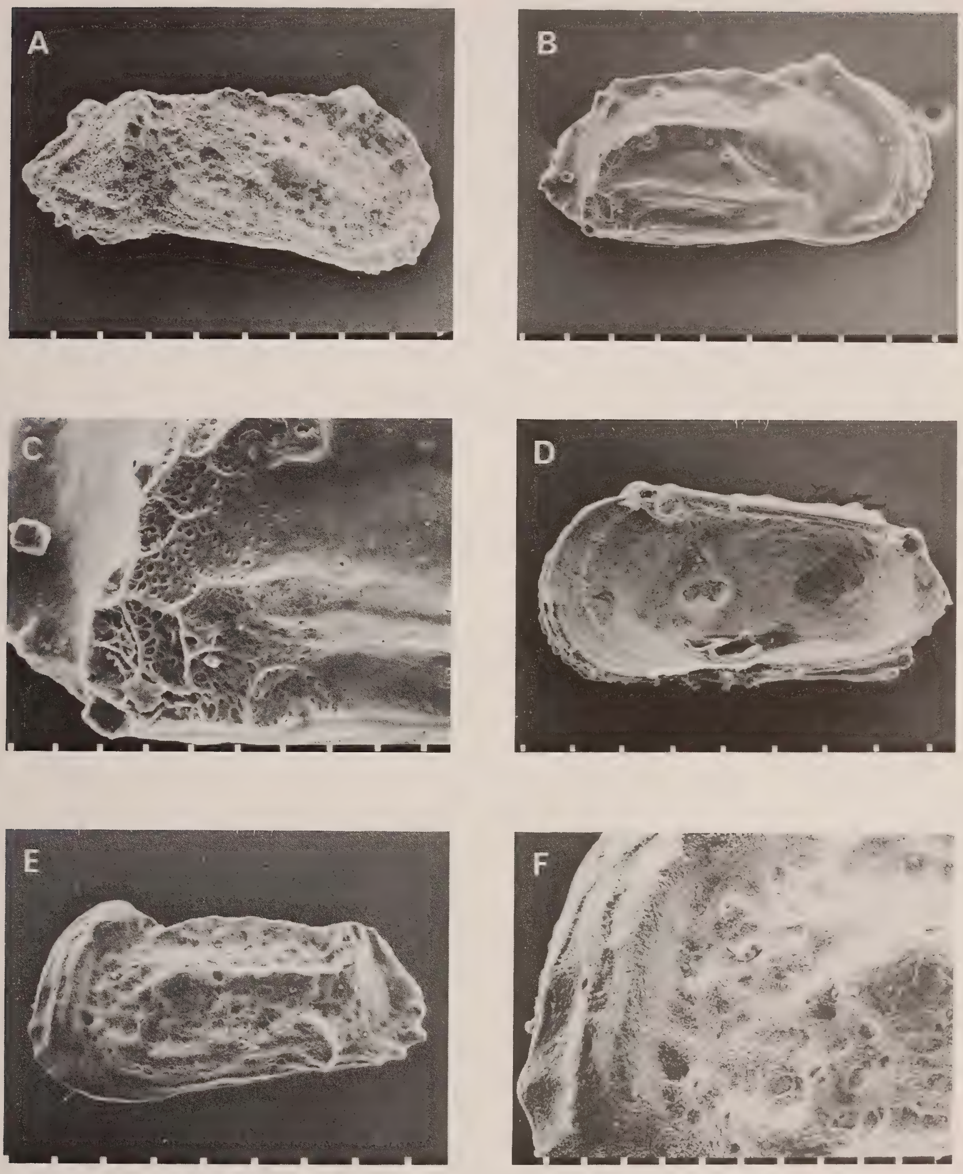


Fig. 29. A. *Isocythereis? ndumuensis* sp. nov., SAM–PC6097, RV, locality 178, Ndumu, Zululand, Albian VI. B–D. *Cythereis agulhasensis* Dingle, 1971, holotype, SAM–PC6098, RV, TBD 1266, Agulhas Bank, Upper Aptian–Albian. B. External lateral view. C. Detail postero-ventral area. D. Interior view. E–F. *Makatinella tritumida* gen. et sp. nov., holotype, SAM–PC6099, RV, locality 171–1, Mlambongwenya Spruit, Zululand, Aptian IV. E. External lateral view. F. Detail anterior area.
Scale bars: A–B, D–E = 100μ, C, F = 30μ.

Makatinella tritumida sp. nov.

Figs 29E–F, 30A–D

Derivation of name

Latin *tres tumor*: reference to three pustules postadjacent to AM rim.

Holotype

SAM–PC6099, LV, locality 171–1, Makatini Formation, Mlambongwenya Spruit, Aptian IV.

Paratypes

SAM–PC6101, C, as above.

SAM–PC6100, C, locality 171–21, Makatini Formation, Mlambongwenya Spruit, Albian III.

Diagnosis

Species with prominent AM rim and three pustules postadjacent to it.

Description

External features. Carapace elongate rectangular, AM broadly and asymmetrically rounded, DM and VM straight with no posterior convergence, PM asymmetrically pointed so that posteroventral part forms continuation of VM. Posteroventral and anteroventral margins bear short stout spines. Anterior hinge ears prominent, rounded, and forming highest points of the valves. In dorsal view, posterior area compressed, widest part of valve in posterior one third. Eye-spots large, set below hinge ears. Lateral surface bears three prominent ridges: dorsal ridge is sharp and straight or slightly convex dorsally, starting behind anterior hinge ear and running to a prominent posterodorsal corner where a short transverse ridge abuts at a right angle; median ridge is narrow and sharp, running from a prominent rounded SCT to the aforementioned transverse ridge; ventral ridge has upturned anterior end and terminates posteriorly in a ventrally projecting spur. There is a prominent AM ridge that runs from the eye-spot to about three-quarters down the AM where it abruptly terminates. Surface ornamentation ranges from smooth with a few scattered pustules, to coarsely but indistinctly recticulate. All varieties bear three hollow pustules postadjacent to the AM ridge.

Interior features. Not well seen, but hinge amphidont with large arches over the TE in LV. Elements apparently smooth, but all specimens were badly worn. MS in central pit, apparently V-shaped anterior scar and four adductors. MA narrow, *c*. 15–16 RPC in anterior RV.

Remarks

In many aspects of general shape and ornamentation *M. tritumida* resembles *Sergipella transatlantica* Krömmelbein, 1967, as illustrated by Grosdidier

(1979) from the late Aptian to early Albian of Gabon, and recorded from the Albian Riachuelo Formation of eastern Brazil by Krömmelbein (1967, 1972). The two species differ in the shape of their posteroventral regions, with *S. transatlantica* having a sharp upswing to a centrally pointed PM outline.

Dimensions (mm)

	length	height
6099	0,80	0,40
6100	0,90	0,46
6101	0,73	0,38

Age and distribution

This species is known to range Aptian IV to Cenomanian III in the Mlambongwenya Spruit (Aptian IV to Albian III) and Ndumu (Cenomanian II to III) regions of Zululand.

Makatinella inflata sp. nov.

Figs 30E–F, 31A–C

Derivation of name

Latin *inflata*: reference to plump, inflated nature of carapace.

Holotype

SAM–PC6102, C, locality 153, Mzinene Formation, Mantuma Rest Camp, Mkuze area, Albian III.

Paratypes

SAM–PC6103, C, as above.
SAM–PC6104, LV, as above.
SAM–PC6105, RV, as above.
SAM–PC6106, C, as above.

Diagnosis

Species with inflated aspect, subdued surface ornamentation, distinct downturned posteroventral margin.

Description

External features. Subquadrate lateral outline, AM broadly and asymmetrically rounded. DM and VM straight with little or no convergence posteriorly. PM asymmetric, ventrally deflected with short stubby spines. Anterior hinge ear prominent, no AM rim. There are three longitudinal ridges: dorsal ridge is slightly dorsally convex, has a downturned anterior end, and terminates at a sharp right angle corner; median ridge starts at a large but indistinct SCT and terminates directly below the termination of the dorsal ridge; and ventral ridge is low and indistinct and is upturned at its posterior end. Valve surface smooth except for indistinct nodes and pustules. In dorsal view carapace is arrowhead-shaped.

Internal features. Not well preserved. MA moderate to narrow, 14–15 RPC anteriorly. Hinge amphidont, all elements apparently smooth, but no unworn specimens available. PTE in LV lies in an arched recess.

Remarks

M. inflata differs from the type species in lacking an AM ridge, in being more inflated overall, in having less well-defined longitudinal ridges, and having a less angular outline in dorsal view with maximum width over SCT, compared to maximum width over the median ridge in the posterior third in *M. tritumida*.

Dimensions (mm)

	length	height	width
6102	0,72	0,40	
6103	0,69	0,34	
6104	0,72	0,35	
6105	0,74	0,36	
6106	0,72		0,37

Age and distribution

This species is known to range Aptian IV to Albian III in the Mkuze and Mlambongwenya Spruit areas of northern Zululand.

Family **Schulerideidae** Mandelstam, 1959

Genus *Pirileberis* Grekoff, 1963

Pirileberis makatiniensis sp. nov.

Figs 31D–F, 32, 33A

Derivation of name

Locality of type specimens on the Makatini Flats, northern Zululand.

Holotype

SAM–PC6107, LV, locality 171–21, Mlambongwenya Spruit, Mzinene Formation, Albian III.

Paratypes

SAM–PC6108, C, as above.
SAM–PC6109, RV, as above.
SAM–PC6110, RV, as above.

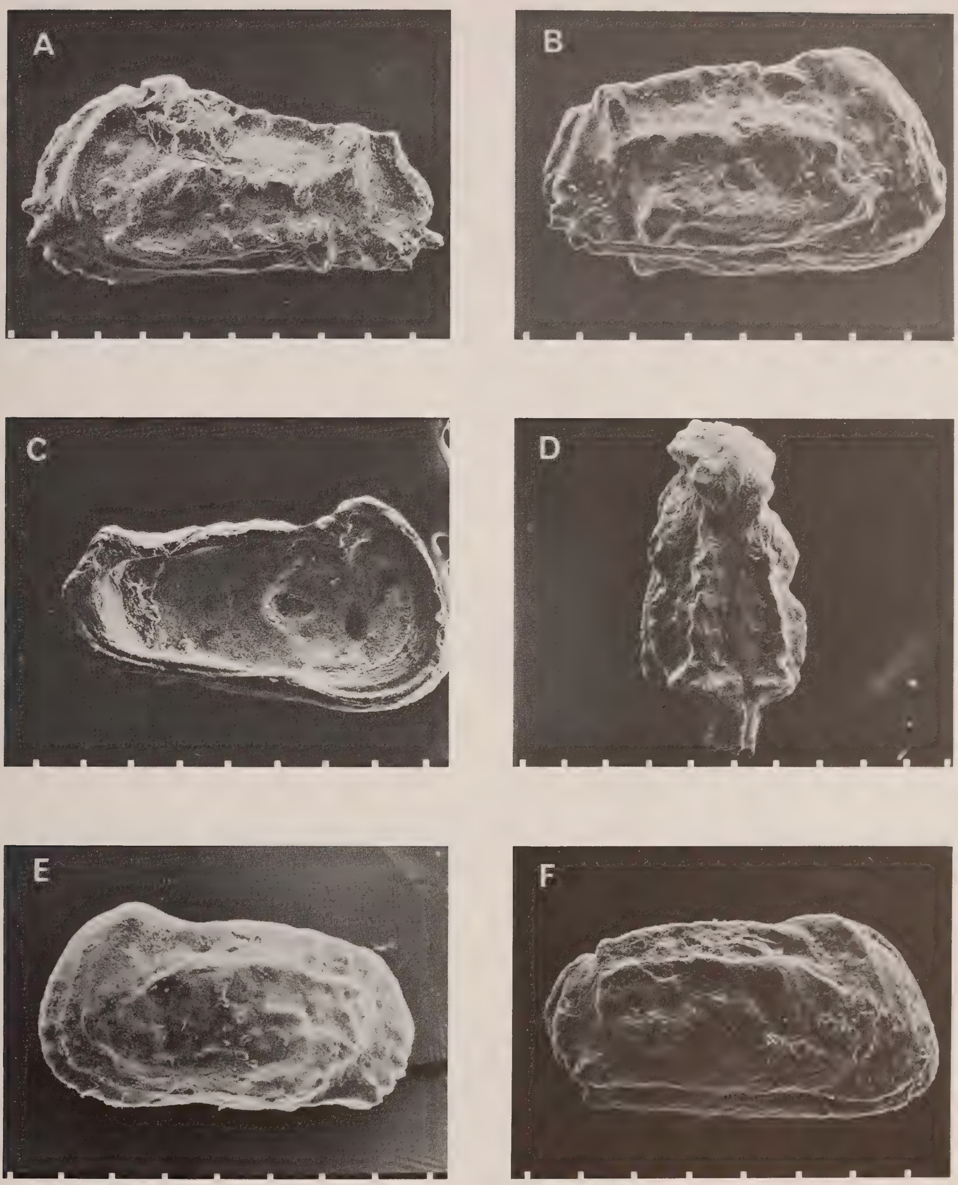


Fig. 30. A–F. *Makatinella*, gen. nov. A–D. *M. tritumida* gen. et sp. nov., locality 171, Mlambongwenya Spruit, Zululand. A. SAM–PC6100, LV, bed 21, Albian III. B–D. SAM–PC6101, bed 1, Aptian IV. B. External lateral RV. D. Dorsal view. C. SAM–PC6099, LV interior view, bed 1, Aptian IV. E–F. *M. inflata* gen. et sp. nov., locality 153, Mkuze, Zululand, Albian III. E. Holotype, SAM–PC6102, LV. F. SAM–PC6103, RV. Scale bars = 100μ.

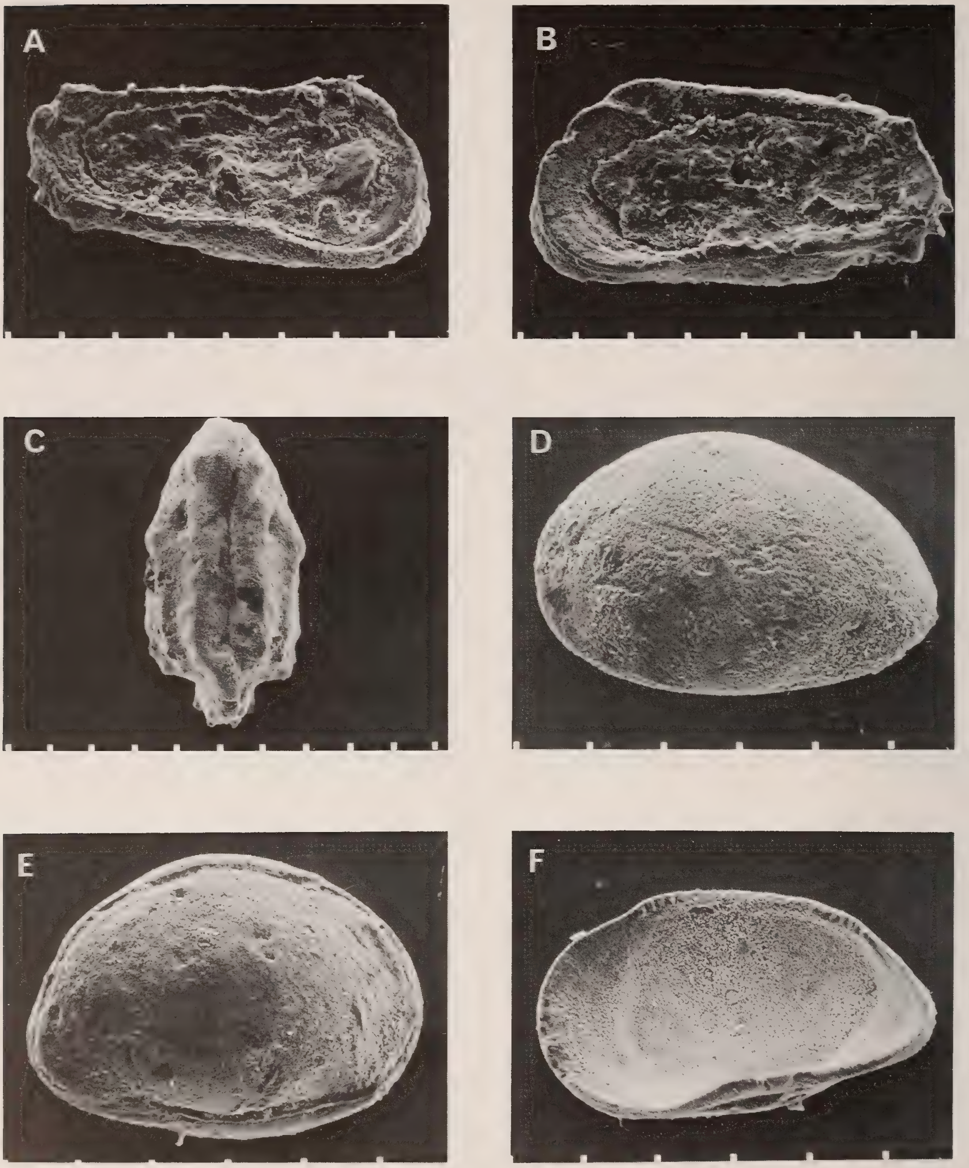


Fig. 31. A–C. *Makatinella inflata* gen. et sp. nov., locality 153, Mkuze, Zululand, Albian III. A. SAM–PC6104, LV internal view. B. SAM–PC6015, RV internal view. C. SAM–PC6106, C, dorsal view. D–F. *Pirileberis makatiniensis* sp. nov., locality 171–21, Mlambongwenya Spruit, Zululand, Albian III. D. Holotype, SAM–PC6107, LV. E. SAM–PC6108, RV. F. SAM–PC6109, RV internal view.
Scale bars = 100μ.

Diagnosis

Species with curved DM, weakly convex VM, and slightly ventrally deflected PM apex.

Description

External features. Plump ovate aspect in lateral view. AM broadly rounded, DM convex, VM weakly convex, PM acutely rounded with apex directly slightly ventrally. Highest point of valve at mid-length. Valve surface smooth.

Internal features. MA moderately wide, with numerous (*c*. 15) fine RPC anteriorly. Hinge merodont, gently curved: in RV ATE has five teeth, PTE has six teeth, ME is a crenulate groove; in LV TE are sockets with ventral ledges, ME is a curved denticulate bar and a narrow, overhung accommodation groove. MS consist of a curved row of four rounded adductors and a large rounded anterior scar (Fig. 32).

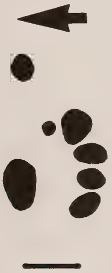


Fig. 32. Muscle scars of *Pirileberis makatiniensis* sp. nov., SAM–PC6109, RV, locality 171–21, Mlambongwenya Spruit, Albian III.
Scale bar = 30 μ.

Remarks

P. makatiniensis differs from the type species (*P. progonata* Grekoff, Kimmeridgian to Valanginian of Madagascar) in having a straighter VM in lateral view, its line of greatest length well below mid-height, and in its MS pattern, which has the anterior scar in a more ventral position. *P. makatiniensis* differs from *P. mkuzensis* sp. nov. in details of lateral outline, hinge structure, and MA.

Dimensions (mm)

	length	height
6107	0,53	0,35
6108	0,52	0,37
6109	0,53	0,30
6110	0,53	0,35

Age and distribution

P. makatiniensis is known to range Aptian IV to Albian III (Makatini and Mzinene formations) in the Mkuze (locality 150) and Mlambongwenya Spruit (locality 171) areas of Zululand.

Pirileberis mkuzensis sp. nov.

Fig. 33B–E

Derivation of name

Locality of type specimens in the Mkuze area, northern Zululand.

Holotype

SAM–PC6111, RV, locality 153, Mantuma rest camp, Mkuze Game Park, Mzinene Formation, Albian III.

Paratypes

SAM–PC6112, LV, as above.
SAM–PC6113, C, as above.
SAM–PC6114, LV, as above.

Diagnosis

Species with subtriangular outline of LV in lateral view.

Description

External features. Asymmetrically rounded AM. DM and VM converge toward small, bluntly rounded PM. DM is straight, VM gently convex. Highest point of valve immediately anterior of mid-length. In LV lateral outline is subtriangular. Valve surface smooth.

Internal features. MA narrow, with about nine fine, indistinct anterior RPC that are grouped in the lower half of margin along axis of greatest length. Hinge merodont. In RV, ATE and PTE strong, of equal size, with six teeth; ATE inclined at angle to main hinge line. ME is a straight denticulate groove above which lies a narrow bar. In LV structures are complementary, including a narrow accommodation groove. MS not seen.

Remarks

P. mkuzensis differs from the type species (*P. progonata* Grekoff) in possessing a straighter VM, particularly in LV, and fewer RPC (9 cf. 20–24). It can be distinguished from *P. makatiniensis* sp. nov. on details of lateral outline, hingement, and number of RPC.

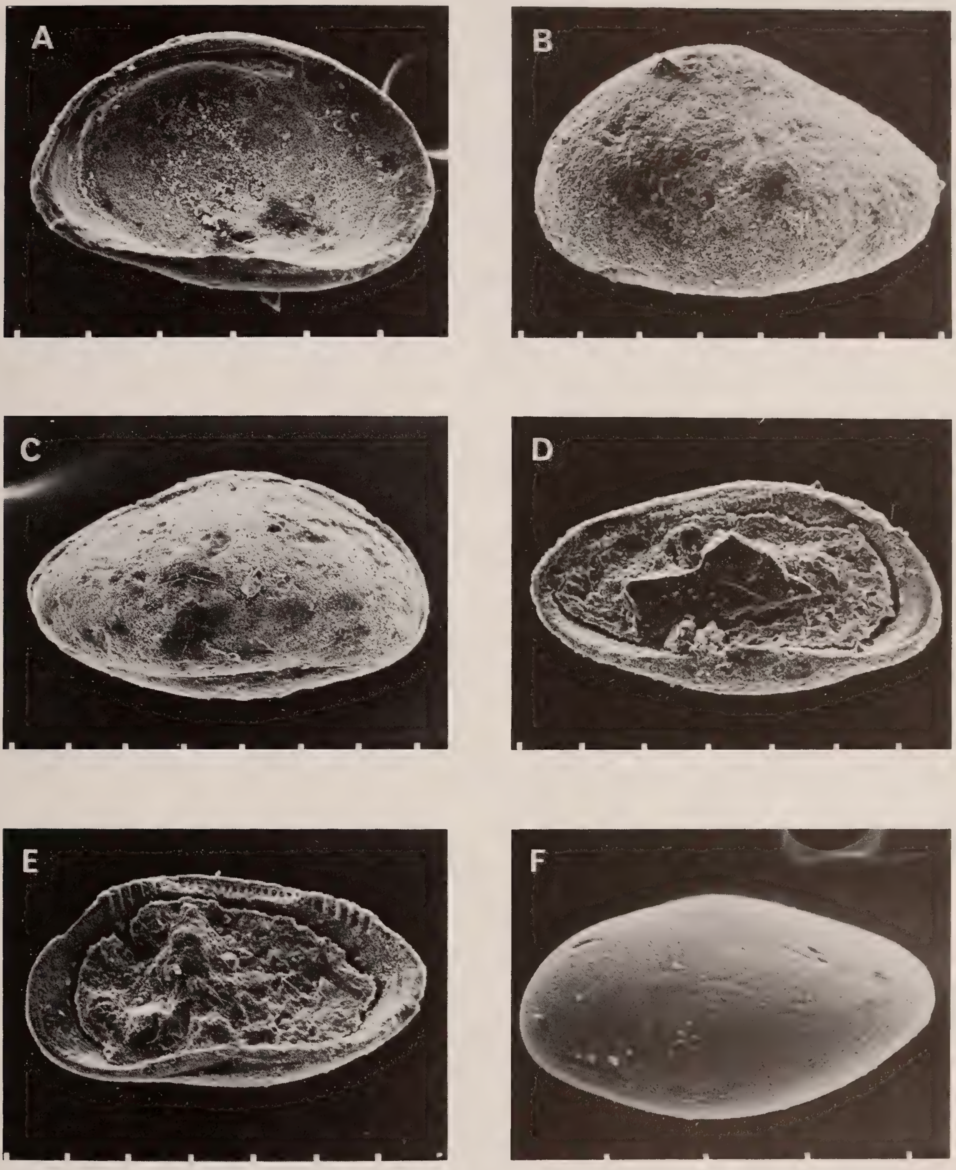


Fig. 33. A. *Pirileberis makatiniensis* sp. nov., SAM–PC6110, LV, interior view, locality 171–21, Mlambongwenya Spruit, Zululand, Albian III. B–E. *Pirileberis mkuzensis* sp. nov., locality 153, Mkuze, Zululand, Albian III. B. SAM–PC6112, LV. C. SAM–PC6113, RV. D. SAM–PC6114, LV internal view. E. Holotype, SAM–PC6111, RV, internal view. F. *Asciocythere? dubia* sp. nov., SAM–PC6116, LV, DSDP 330, core 1/cc, early–middle Albian.

Scale bars = 100μ.

Dimensions (mm)

	length	height
6111	0,64	0,34
6112	0,67	0,41
6113	0,69	0,40
6114	0,65	0,35

Age and distribution

P. mkuzensis is known to range Aptian IV to Albian III (Mkatini and Mzinene formations), in the Mkuze area of Zululand (localities 150 and 153).

Genus *Asciocythere* Swain, 1952

Asciocythere? dubia sp. nov.

Figs 33F, 34A–B

Derivation of name

Latin *dubia*, uncertain: reference to uncertain taxonomic status.

Holotype

SAM–PC6115, RV, DSDP 330, core 1/cc, early–middle Albian.

Paratypes

SAM–PC6116, LV, as above.
SAM–PC6117, LV, as above.

Diagnosis

Smooth species with elliptical LV, more elongate RV, hinge modified hemimerodont.

Description

External features. LV larger than RV. LV elliptical with round AM and narrow rounded PM, DM and VM strongly convex, outline tapering posteriorly. Highest point of valve in front of mid-length, maximum length at about mid-height. RV more elongate than LV, with straight VM, convex DM. Surface entirely smooth. No eye-spots.

Internal features. Narrow MA. MS not seen. Hinge modified hemimerodont: in RV small elongate weakly crenulate TE project dorsally, ME is a smooth, straight bar with a narrow accommodation groove; in LV TE are narrow sockets under the DM with an ME depression and DM overhang.

Remarks

This species is tentatively placed in the genus *Asciocythere* on the grounds of general shape and hinge, although in detail it is not very close to any species so far assigned to the genus. The type species *A. rotunda* (Vanderpool 1928) has a similar lateral outline to *A? dubia* but is less elliptical and has a conventional hemimerodont hinge.

Asciocythere is a typical Upper Jurassic to mid-Cretaceous taxon from North America (see Swain 1972; Neale 1977), and Swain (1976) has recorded an *Asciocythere* sp. from DSDP site 137 (core 11–1/86–92 cm) off north-western Africa in ?Cenomanian strata. The latter is a punctate species with a weakly convex VM. Damotte (1979) records *Asciocythere* sp. 68 from the Aptian of DSDP 400A (core 68–1/72–73 cm) in the north-western Bay of Biscay, but her specimen has a more strongly arched LV DM and lacks the upswept posteroventral outline of *A? dubia*.

Dimensions (mm)

	length	height
6115	0,51	0,26
6116	0,41	0,22
6117	0,41	0,23

Age and distribution

A? dubia is known only from the early–middle Albian at DSDP site 330 (core 1/cc), where it is rare (*c.* 3%).

Family uncertain

Aitkenicythere Bate, 1976

Aitkenicythere? striosulcata sp. nov.

Fig. 34C–F

Derivation of name

Latin *striatus* (striation) + *sulcus* (sulcus): reference to striate ornamentation and prominent dorsomedian sulcus.

Holotype

SAM–PC6119, RV, DSDP 327, core 21–3/71–76 cm, early Albian.

Paratypes

SAM–PC6118, LV, DSDP 327, core 21–3/71–76 cm, early Albian.
SAM–PC6120, RV, DSDP 330, core 1/cc, early–middle Albian.

Diagnosis

Species with fine longitudinal ribs and a prominent dorsomedian sulcus.

Description

External features. Elongate subquadrate in lateral view. AM broadly and symmetrically rounded, typically with a border frill, PM RV asymmetrically acuminate with maximum length below mid-height, PM LV truncated with weak posteroventral extension. DM straight, but with small prominent concavity about mid-length, VM straight in LV, slightly concave in RV. DM and VM converge posteriorly. Surface ornamented with fine, broken, longitudinal ribs and weak intercostal muri that produces reticulation. There is a dominant median rib that runs from near the AM across the mid-point of the valve, posterior of which it rises and has a dorsally convex hook. There are numerous wide, well-spaced pustulate normal pore openings on the lateral surface. In the dorsal and median part of the valve there is a low sulcus across which median ribs are deflected and converge. A further prominent rib runs obliquely across the anterior CA.

Internal features. MA wide, apparently no vestibules and few (?five) anterior RPC. Hinge lophodont with long straight ME bar in LV with two deep rounded TE sockets that are partly enclosed by the duplicature. Posteroventral MA of RV is apparently wider than corresponding structure in LV. NPC openings are prominent.

Remarks

Position within genus is provisional. *A? striosulcata* compares favourably with the type species *A. gracilis* (Bate, 1975), but is not so slim in dorsal view, and has a slightly different ornamentation.

Dimensions (mm)

	length	height
6110	0,42	0,22
6119	0,42	0,22
6120	0,33	0,17

Age and distribution

A? striosulcata ranges early–middle Albian at DSDP site 330 (core 1–1/cc to 112–116 cm) and early Albian at DSDP site 327 (core 21–3/71–76 cm), where it is rare (3–5 % at 330) to abundant (31 % at 327).

Aitkenicythere? sp. 327/18

Fig. 35A

Acrocythere? sp. A Oertli, 1974: 949, pl. 7 (fig. 6).

Remarks

One carapace of a small cytheracean with three prominent blade-like longitudinal ridges, the dorsal of which is continuous with the AM ridge. Although no internal views are available, this specimen appears close to *Aitkenicythere gracilis* (Bate, 1975), and it possibly belongs to the same species as a specimen identified as *Acrocythere?* sp. A by Oertli from DSDP site 261 off north-western Australia.

The specimen differs from the type species of *Aitkenicythere* by being less laterally compressed and by possessing an AM ridge.

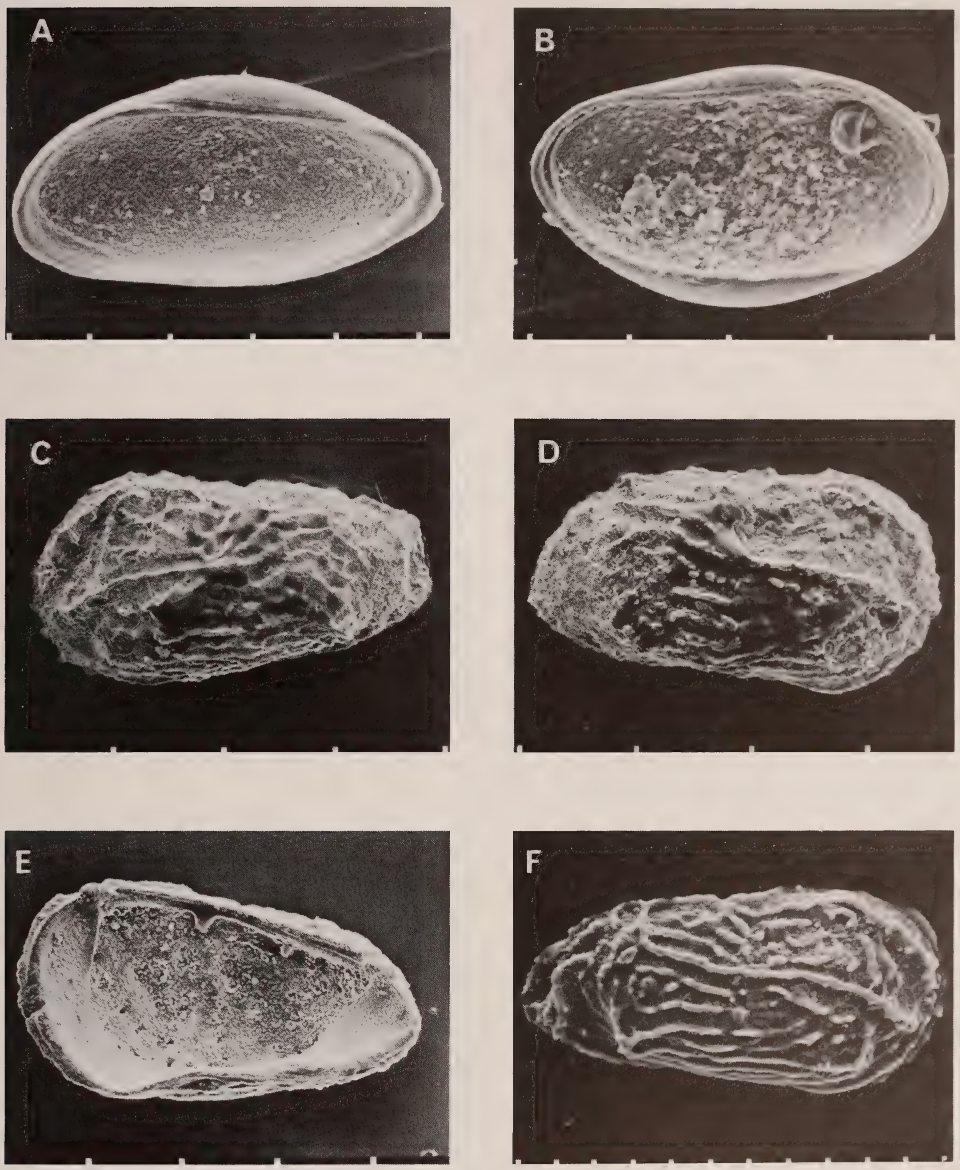


Fig. 34. A–B. *Asciocythere? dubia* sp. nov., DSDP 330, core 1/cc, early–middle Albian. A. Holotype, SAM–PC6115, RV internal view. B. SAM–PC6117, LV internal view. C–F. *Aitkenicythere? striosulcata* sp. nov. C–D. DSDP 327, core 21–3/71–76 cm, early Albian. C. Holotype, SAM–PC6119, LV. D. SAM–PC6118, RV. E–F. SAM–PC6120, RV, DSDP 330, core 1/cc, early–middle Albian. E. Internal view. F. External lateral view. Scale bars: A–E = 100μ, F = 30μ.

Dimensions (mm)

	length	height
6121	0,37	0,18
Holotype of *Aitkenicythere gracilis* (Bate, 1975)	0,41	0,21
Acrocythere? sp. A Oertli 1974	0,41	0,21

Age and distribution

Aitkenicythere? sp. 327/18 occurs at one level in the middle Albian of DSDP 327 (core 18–2/51–55 cm) on the Falkland Plateau.

Acrocythere? sp. A Oertli occurs in an Upper Oxfordian horizon in DSDP 261 (core 33–1/0–20 cm) off north-western Australia.

Aitkenicythere gracilis (Bate, 1975) (type species) occurs in the Middle or Upper Kimmeridgian (samples B219 & B223) of the Mandawa anticline, Tanzania.

Indet. sp. 1

Fig. 35B

Remarks

One carapace of a distinctly shaped and ornamented species. Overall the carapace is plump, with a sharply upswinging posteroventral margin. PM apex is above mid-height. The ornamentation consists of narrow vertical ridges arranged concentrically about the mid-length.

Bertels (1969) has described a species with similar ornamentation and shape from the Lower Maastrichtian of Argentina *(Semicytherura? similis)*.

Age and distribution

Aptian III, Makatini Formation, locality 150–11, northern side of Nhlohlela Pan, Mkuze area, northern Zululand.

Indet. sp. 2

Fig. 35C

Remarks

One poorly preserved carapace showing faint longitudinal lineations along the ventromedian surface. Shape and ornamentation reminiscent of *Progonocythere reticulata* Dingle (in Dingle & Klinger 1972) from the ?Portlandian to Valanginian of the southern Cape coast (see McLachlan *et al*. 1976*b*).

Age and distribution

Aptian IV, Makatini Formation, locality 150–21, northern side of Nhlohlela Pan, Mkuze area, northern Zululand.

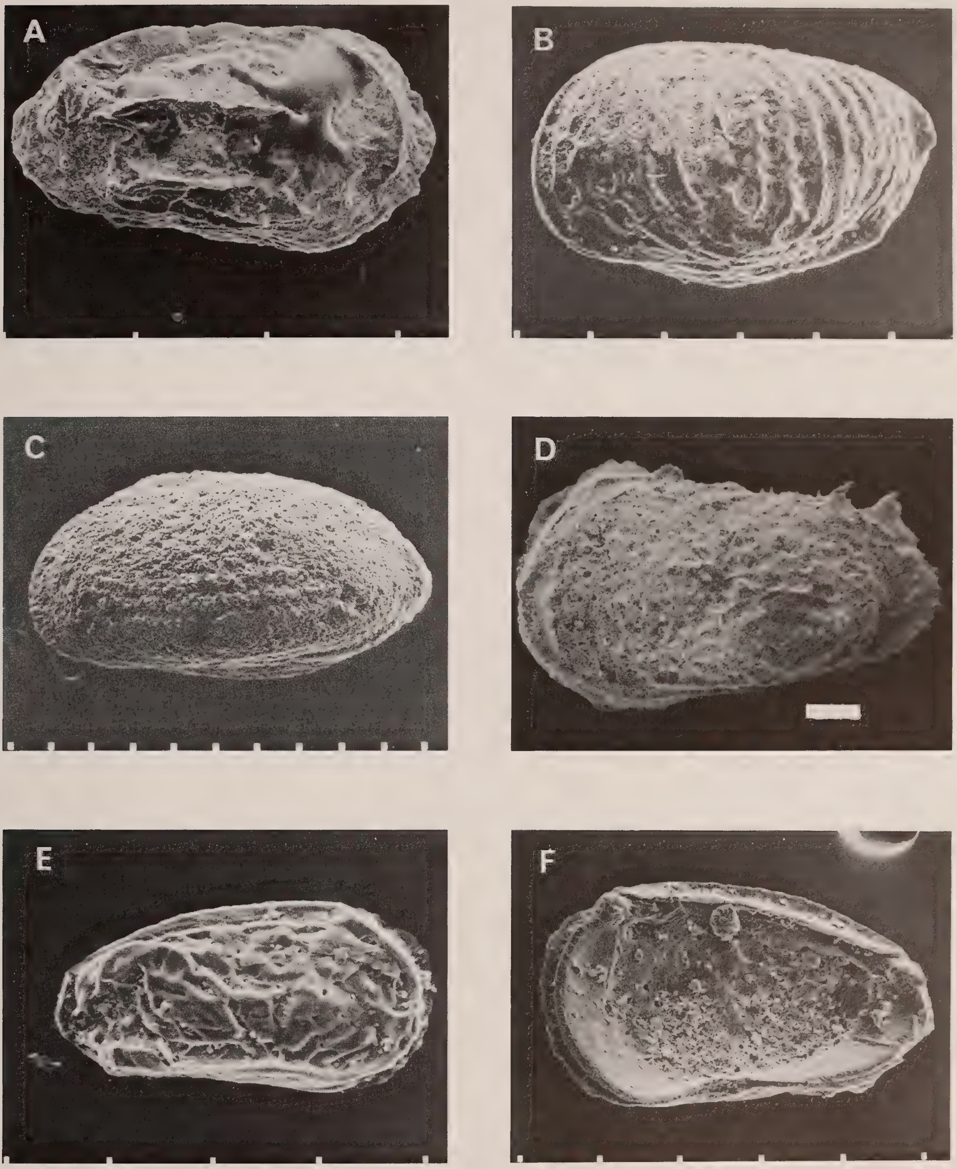


Fig. 35. A. *Aitkenicythere?* sp. 327/18, SAM–PC6121, RV, DSDP 327, core 18–2/51–55 cm, middle Albian. B. Indet. sp. 1, SAM–PC6122, LC, locality 150–11, Mkuze, Zululand, Aptian III. C. Indet. sp. 2, SAM–PC6123, LV, locality 150–21, Mkuze, Zululand, Aptian IV. D. Indet. sp. 327/16A, LV, DSDP 327, core 16–4/66–70 cm, middle Albian. E–F. Indet. sp. 330/1, SAM–PC6124, RV, DSDP 330, core 1/cc, early–middle Albian. E. External lateral view. F. Internal view.
Scale bars = 100 μ.

Indet. sp. 330/1

Fig. 35E–F

Remarks

Two valves of a small, heavily ornamented species with an overall leptocytherid appearance. It has wide MA and a lophodont hinge, a prominent ridge along the DM, and a rib that is continuous round the AM and VM. NPC are conspicuous.

Age and distribution

Occurs in the early-middle Albian of DSDP 330 (core 1/cc).

Indet. sp. 327/16A

Fig. 35D

Remarks

Single valve, probably juvenile of a blind trachyleberid-like species. Salient features include small median sulcus, inflated posteroventral area, small, flat spine on dorsal part of posterior margin, reticulate, hirsute ornamentation, lophodont hinge. MS consist of V-shaped anterior scar and vertical row of four posterior scars.

Age and distribution

Occurs in the middle Albian of DSDP 327 (core 16–4/66–70 cm).

Indet. sp. 327/16B

Fig. 36A–B

Remarks

Shape reminiscent of neocytherid taxa with reticulate ornamentation. The hinge is lophodont with long narrow TE.

Age and distribution

Occurs in the middle Albian of DSDP site 327 (core 16–4/66–70 cm).

Indet. sp. 327/18

Fig. 36C

Remarks

Small species with a strongly arched DM, straight VM, acuminate PM, and rounded AM. No internal views seen.

Age and distribution

Occurs in the middle Albian of DSDP site 327 (core 18–2/51–55 cm).

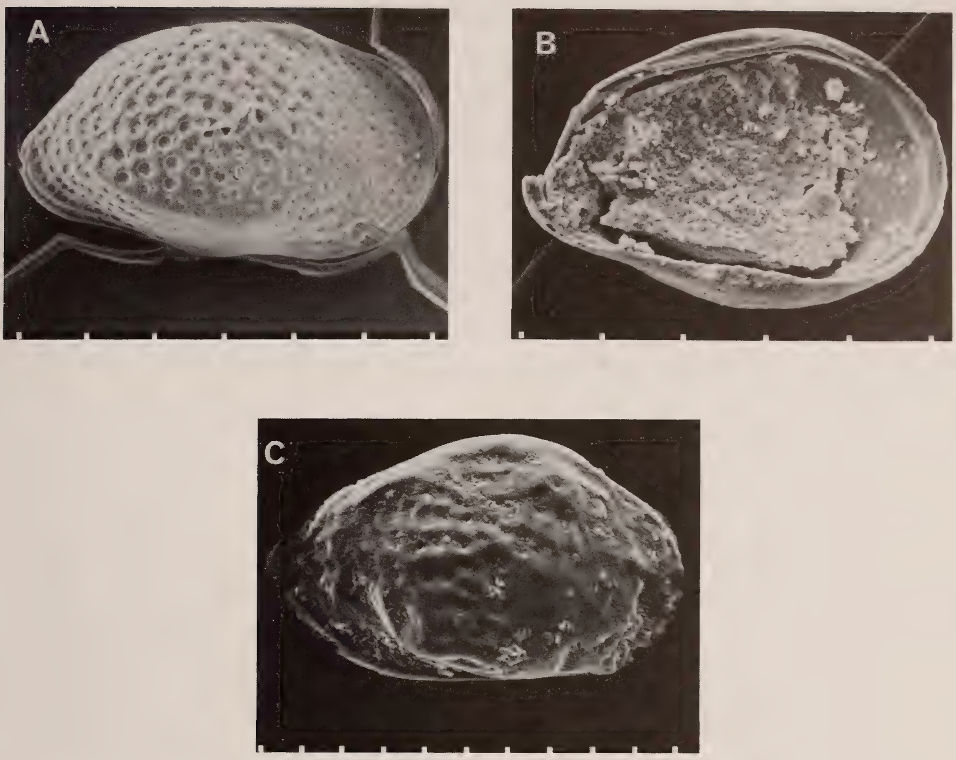


Fig. 36. A–B. Indet. sp. 327/16B, DSDP 327, core 16–4/68–70 cm, middle Albian. A. SAM–PC6127, RV. B. SAM–PC6126, LV internal view. C. Indet. sp. 327/18, SAM–PC6128, RV, DSDP 327, core 18–2/51–55 cm, middle Albian.
Scale bars: A–B = 100μ, C = 30μ.

DISCUSSION

All the ostracods encountered were benthic types, and 51 species belonging to 26 genera (with 6 species unallocated) were identified from the Aptian to Cenomanian strata of south-east Africa (Agulhas Bank and Zululand) and the Falkland Plateau (DSDP sites 327 and 330). In this section the faunas and their palaeoecological and biostratigraphical implications will be discussed, followed by a regional assessment of their distribution in the light of mid-Cretaceous palaeogeographic reconstructions of this part of Gondwanaland.

FALKLAND PLATEAU

Altogether 28 species belonging to 16 genera (with 4 species unallocated) have been recorded from the two DSDP sites on the east Falkland Plateau: site 327 (20 species, 14 genera); site 330 (17 species, 13 genera). Their vertical distribution and relative abundances are shown in Table 6.

Palaeoecology

Although a relatively rich fauna was obtained from DSDP site 330, only three samples contained specimens, and their limited vertical distribution (early–middle Albian, Fig. 4) makes the determination of palaeoecological trends uncertain. In contrast, the nine fossiliferous samples from site 327 span early to late Albian time (Fig. 4), and allow some preliminary palaeoeocological determinations to be attempted for comparison with those already available from Sliter (1977) and Scheibnerova (1981).

Figure 37 and Table 6 show various statistical data on species and higher taxal trends from DSDP 327. Throughout the section the populations are dominated by *Robsoniella falklandensis* (37–56% of total fauna), which is usually at least twice as abundant as the next most common type. Three species alternate in this secondary role: *Isocythereis sealensis* (0–10%); *Cytherella bensoni* (7–19%); and *Arculicythere tumida* (1–18%). The taxonomic position of *Robsoniella* is uncertain and, although it was originally placed in the family Healdiidae by Kusnetsova (in Mandelstam *et al.* 1956), the *Treatise* authors on ostracods (Moore 1961) were not happy about the situation. We have placed it in the Bairdiidae because of, *inter alia*, its similarity to *Bythocypris richardsbayensis* from the Upper Cretaceous of South Africa. *Bairdoppilata* sp. 2, the only other representative of the family, is locally fairly common, but does not occur consistently throughout the borehole.

Considering the various populations in terms of a Cytheracea–Cytherellidae–Bairdiacea + Cypridacea (CCBC) triangular diagram (Fig. 38) all, with the exception of one, lie in the 200–100 m water-depth field of the predictive CCBC plot of Dingle (1981, fig. 75). The exception (core 16–4/66–70 cm, sample 7) lies in the field predicted for water depths greater than 500 m. Dingle (1980, 1981) constructed this diagram from ostracod populations collected mainly from Zululand and, in terms of the assemblages originally plotted, all the Falkland Plateau populations lie outside them, or in one case (core 21–4/130–134 cm, sample 1) just inside the border (of assemblage 4a).

Figure 37 shows that the relative abundances of the three groups represented on the CCBC plot remain fairly constant up the borehole, suggesting that the overall sedimentary environment remained similar during the entire early to late Albian period represented by cores 21 to 15. This conclusion is in broad

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Fig. 37. Variations in selected components of the Albian ostracod populations at DSDP site 327 on the Falkland Plateau. a—higher taxa used in the Cytheracea, Cytherellidae, Bairdiacea + Cypridacea (CCBC) triangular diagram (Fig. 38) plotted as percentage of total ostracod population; b—four important genera plotted as percentage of total ostracod population; c—the subfamilies Cytherurinae and Trachyleberidinae (the genus *Isocythereis*) plotted as percentage of Cytheracea; d—micro-ostracods (see Table 6 for species) plotted as percentage of total ostracod population. The vertical scales on a–d are percentages, and values are smoothed using a three-point running mean; e—shows temporal distribution of minor species, numbered according to Table 5. Species with stars are also found at DSDP site 330. The horizontal scale is by core and informal sample number (see Table 6).

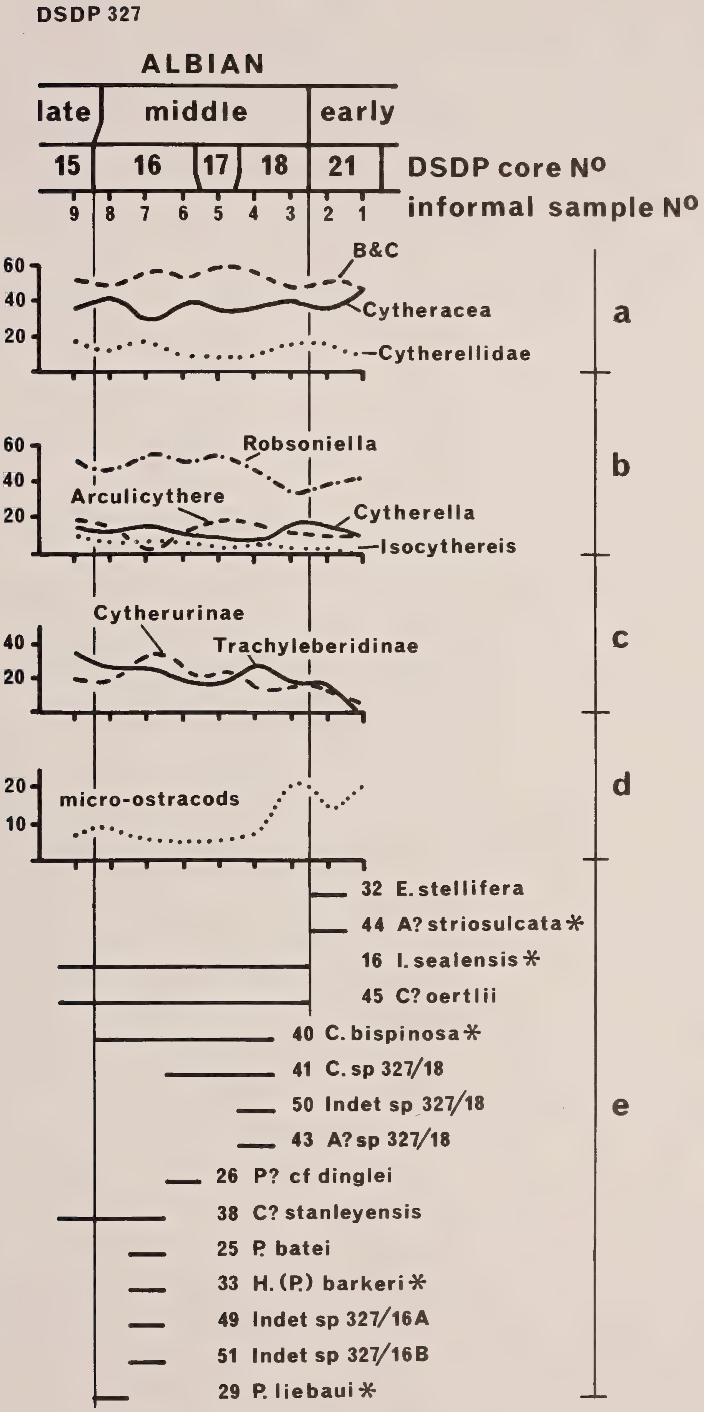
DSDP 327
ALBIAN
late
middle
early
15
16
17
18
21
DSDP core Nº
9 8 7 6 5 4 3 2 1
informal sample Nº
60
40
20
B&C
Cytheracea
Cytherellidae
a
60
40
20
Robsoniella
Arculicythere
Cytherella
Isocythereis
b
40
20
Cytherurinae
Trachyleberidinae
c
20
10
micro-ostracods
d
32 E. stellifera
44 A? striosulcata *
16 I. sealensis *
45 C? oertlii
40 C. bispinosa *
41 C. sp 327/18
50 Indet sp 327/18
43 A? sp 327/18
26 P? cf dinglei
38 C? stanleyensis
25 P. batei
33 H. (P.) barkeri *
49 Indet sp 327/16A
51 Indet sp 327/16B
29 P. liebaui *
e

TABLE 6

Distribution of ostracods in Albian sediments of DSDP sites 327 & 330, Falkland Plateau

Numbers in each column are percentages of total ostracod population.

	DSDP site no.	330			327									
	Age	early–middle Albian			early Albian		middle Albian						late Albian	Cenom
	Core no.	2	1		21		18		17	16			15	14
	section	2	1		4	3	6	2	2	6	4	1	2	6
	Interval (cm)	122–126	cc	112–116	130–134	71–76	106–110	51–55	108–113	126–130	66–70	55–59	132–136	126–130
Sp. no.	Informal sample no.	1	2	3	1	2	3	4	5	6	7	8	9	
25	*Procytherura batei*	3									18			*
15	*Arculicythere tumida*	38	34	24	22	8	—	22	29	3	—	—	35	*
9	*Robsoniella falklandensis*	54	19	32	70	15	38	59	50	61	42	63	38	*
1	*Cytherella bensoni*	5	1	15	5	15	22	—	—	23	6	19	8	*
29	*Pariceratina liebaui*		3	1								3		*
40	*Cytheropteron bispinosa*		13	10				3	—	—	6	3		*m
30	*Pedicythere falklandensis*		1	1										m
31	*Eucytherura rugosa*		1											m
35	*H. (Parahemingwayella) reticulata*		3	1										m
34	*H. (P.) dalzieli*		10	6										m
33	*H. (P.) barkeri*		3								3			*m
36	*Hemiparacytheridea ewingensis*		2											m
37	*H. challengeri*		1											m
39	*Asciocythere? dubia*		3											

7	*Bairdoppilata* sp. 2		2	9		8	22	3		3				*
16	*Isocythereis sealensis*			4			11		14	3	3	9	10	*
32	*Eucytherura stellifera*					8								m
45	*Cytherura? oertlii*						5						2	m
41	*Cytheropteron* sp. 327/18							3		3				m
43	*Aitkenicythere?* sp. 327/18							6						m
50	Indet. sp 327/18							3						
14	*Majungaella?* 327/16									3				
26	*Procytherura* cf. *dinglei*									3				
38	*Collisarboris? stanleyensis*										3		2	m
49	Indet. 327/16A										3			
51	Indet. 327/16B										6			
	Indet. species (various fragments)	2			5	15	22			23	6	19	8	
No. ostracod valves		37	119	110	37	13	37	32	14	31	33	32	48	0
No. spp./sample		4	16	11	4	6	5	7	3	8	9	5	6	0
Diversity (No. spp./100 valves, %)		11	13	10	11	46	14	22	21	26	27	16	13	0
No. spp./site			18							20				
Micro-ostracods: No. spp./sample		0	9	5	0	2	1	3	0	1	3	1	2	0
Micro-ostracos: % total ostracods		0	38	23	0	39	5	15	0	3	12	3	8	0
No. spp. extant (total ostracods)		4	16	11	3	6	6	10	8	10	11	8	6	0

Total no. of species = 28
No. common 327/330 = 10 (36% total)

Total no. of species of micro-ostracods = 14
No. common 327/330 = 3 (21%)

---

* = species common to both sites
m = micro-ostracod (<0,45 mm)

TABLE 6

Distribution of ostracods in Albian sediments of DSDP sites 327 & 330, Falkland Plateau
Numbers in each column are percentages of total ostracod population.

	DSDP site no.	330			327										
	Age	early–middle Albian			early Albian		middle Albian						late Albian	Cenom	
	Core no.	2	1		21		18		17	16			15	14	
	section	2	1		4	3	6	2	2	6	4	1	2	6	
	Interval (cm)	122–126	cc	112–116	130–134	71–76	106–110	51–55	108–113	126–130	66–70	55–59	132–136	126–130	
Sp. no.	Informal sample no.	1	2	3	1	2	3	4	5	6	7	8	9		
25	*Procytherura batei*	3									18				*
15	*Arculicythere tumida*	38	34	24	22	8		22	29	3			35		*
9	*Robsoniella falklandensis*	54	19	32	70	15	38	59	50	61	42	63	38		*
1	*Cytherella bensoni*	5	1	15	5	15	22			23	6	19	8		*
29	*Pariceratina liebaui*		3	1								3			*
40	*Cytheropteron bispinosa*		13	10				3			6	3			*m
30	*Pedicythere falklandensis*		1	1											m
31	*Eucytherura rugosa*		1												m
35	*H. (Parahemingwayella) reticulata*		3	1											m
34	*H. (P.) dalzieli*		10	6											m
33	*H. (P.) barkeri*		3								3				*m
36	*Hemiparacytheridea ewingensis*		2												m
37	*H. challengeri*		1												m
39	*Asciocythere? dubia*		3												m
44	*Aitkenicythere? striosulcata*		4	5		31									*m
48	Indet. sp. 330/1		2												
7	*Bairdoppilata* sp. 2		2	9		8	22	3		3					*
16	*Isocythereis sealensis*			4			11		14	3	3	9	10		*
32	*Eucytherura stellifera*					8									m
45	*Cytherura? oertlii*						5						2		m
41	*Cytheropteron* sp. 327/18							3		3					m
43	*Aitkenicythere?* sp. 327/18							6							m
50	Indet. sp 327/18							3							
14	*Majungaella?* 327/16									3					
26	*Procytherura* cf. *dinglei*									3					
38	*Collisarboris? stanleyensis*										3		2		m
49	Indet. 327/16A										3				
51	Indet. 327/16B										6				
	Indet. species (various fragments)	2			5	15	22			23	6	19	8		
	No. ostracod valves	37	119	110	37	13	37	32	14	31	33	32	48	0	
	No. spp./sample	4	16	11	4	6	5	7	3	8	9	5	6	0	
	Diversity (No. spp./100 valves, %)	11	13	10	11	46	14	22	21	26	27	16	13	0	
	No. spp./site		18							20					
	Micro-ostracods: No. spp./sample	0	9	5	0	2	1	3	0	1	3	1	2	0	
	Micro-ostracos: % total ostracods	0	38	23	0	39	5	15	0	3	12	3	8	0	
	No. spp. extant (total ostracods)	4	16	11	3	6	6	10	8	10	11	8	6	0	

Total no. of species = 28
No. common 327/330 = 10 (36% total)

Total no. of species of micro-ostracods = 14
No. common 327/330 = 3 (21%)

* = species common to both sites
m = micro-ostracod (<0,45 mm)

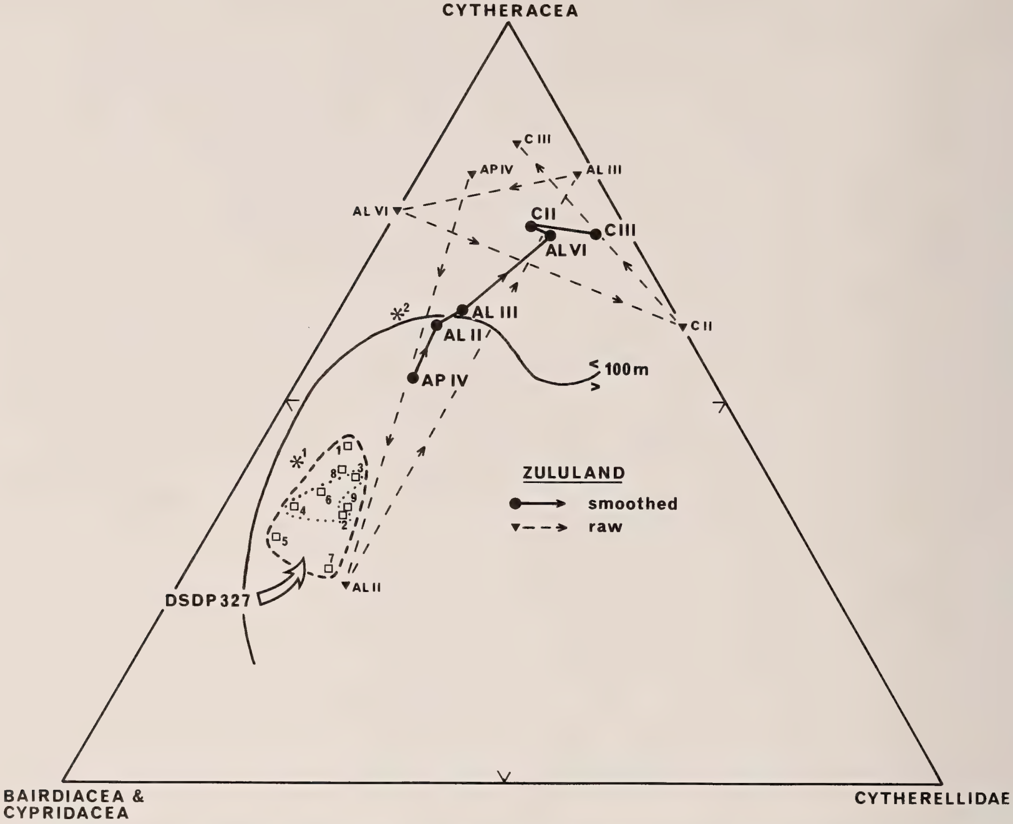

Fig. 38. Triangular (CCBC) plot of the mid-Cretaceous ostracod populations from the Falkland Plateau and Zululand. The DSDP samples are numbered using the informal system shown in Table 6 and are plotted smoothed (3 point means). Populations from site 327 are enclosed by a thick dashed line, and samples containing *Bairdoppilata* sp. 2 are enclosed by a dotted line. Samples from DSDP 330 are plotted as stars: *1 is sample 1, and *2 is a composite population from samples 1 and 2. Samples from Zululand are composites from stage subdivisions and are plotted both smoothed (3 point means), and raw. The 100 m predictive water depth line is taken from Dingle (1982, fig. 75). See text for a discussion of the trends. Abbreviations: AP—Aptian; AL—Albian; C—Cenomanian.

agreement with that reached by Barker *et al.* (1977), and Sliter (1977) on studies of the planktonic foraminifera, which predicted water depths of 100–400 m from the Albian sequence (Barker *el al.* 1977: 44, fig. 7). Sliter (1977: 524) detected a slight reduction in benthic foraminifera numbers up the borehole (cores 21 to 15), which he interpreted as a gradually increasing water depth, as well as an increase in the numbers of planktonic foraminifera from their incoming (few specimens) in core 19, to 35 per cent of total biogenic debris at the base of core 16, with a further rise, after fluctuation to 45 per cent in core 15. Planktonic–benthic foraminiferal ratios calculated from Sliter's (1977) data (Fig. 39) indicate an erratic increase from core 19 (*c.* 0,5, middle Albian) to core 15 (3,46, late Albian). Above this (Cenomanian and Santonian), planktonic foraminifera are very sparse or absent before rising to values of greater than 9,0 in the Campanian–Maastrichtian, which Sliter interprets as representing water depths of 1 500–2 500 m.

Figure 39 shows the planktonic–benthic ratio curve (a) plotted against various trends of the ostracod populations. Planktonic foraminifera appear in core 19 and there are three peaks in the curve above this point. In comparison, the curve of cytheracean ostracods (b) (as percentage of total fauna) shows four high points, and two of these are in, and two out of phase with the foraminiferal peaks. Each of the cytheracean peaks can be related to the dominance of particular higher taxa: the earliest (core 21) is caused by relatively large numbers of micro-ostracods (c) and lies below the level of the appearance of planktonic foraminifera; the second (core 17) lies between two peaks in the planktonic–benthic curve and is related to the large numbers of *Isocythereis sealensis* and *Arculicythere tumida* present at this level (d, e). A peak in the curve for the micro-ostracod distribution does coincide with the first foraminifera peak in core 18, and similarly in core 16 where the numbers of micro-ostracods involved is large enough to result in a peak in the cytheracean curve. At this level there is a low in the values for both *Isocythereis sealensis* and *Arculicythere tumida*. In core 15, the cytheracean peak, which coincides with a peak in the P/B curve, is caused by reinforcement of curves (c), (d), and (e). It appears, therefore, that fluctuations in the percentage of the cytheracean element were caused by alternation in the numbers of micro-ostracods (mostly cytherurids) and combined trachyleberids and progonocytherids, and that neither were consistently in step with increases in the relative numbers of planktonic foraminifera. Consequently, the latter are more likely to reflect changes in degree of access to the open ocean than significant alternations of local sea-level.

Scheibnerova (1981) studied the Albian benthic foraminfera of site 327 and found a relatively rich assemblage of agglutinated and calcareous benthic forms (Table 7), which indicated to her a water depth in the vicinity of 100 m (not exceeding 300–400 m).

The results of plotting the ostracod data from site 330 on to the CCBC diagram (Fig. 38) suggest shallow-water environments in both cases, with the oldest sample (core 2–2/122–126 cm) lying close to the cluster from site 327, and probably representing somewhat shallower water (*c.* 100 m). A mean value for the two samples in core 1 places it within the shallow water (less than 100 m) field of the cytheracean-dominated populations. Although too few samples are available from site 330 for a reliable estimate of palaeoenvironments to be made, the evidence does point to deposition under similar conditions to those that prevailed at the same time (early–middle Albian) at site 327 (*c.* 10 km to the south-west).

Micro-ostracods (< 0,45 mm) (Table 6) are both diverse and relatively abundant in the mid-Cretaceous at site 327 (and 330), and show variations along the length of the hole that may have palaeoenvironmental significance. They are

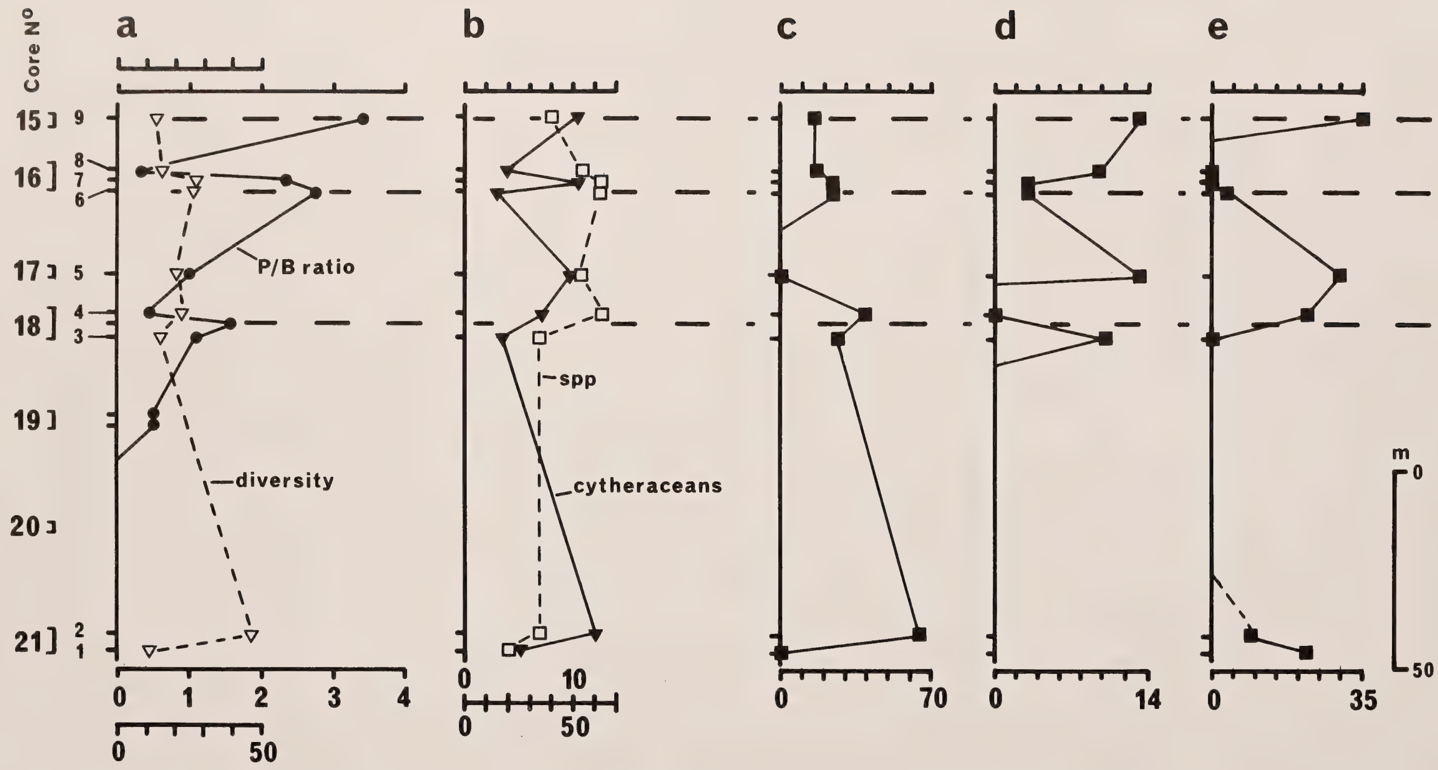

Fig. 39. Distribution of various microfaunal elements in the Albian strata of DSDP site 327.

Vertical scale is in metres, and left column shows core and informal sample numbers (see Table 6 for core section correlation). a—Dots: planktonic/benthic foraminifera ratio calculated from data given in Sliter (1977). The three peaks in this curve run across the whole diagram as dashed lines. Inner horizontal scale refers and is a ratio. Open triangles: ostracod population diversity (no. spp. per 100 specimens). Outer horizontal scale refers and is a percentage. b—Open squares: number of ostracod species extant. Inner horizontal scale refers and is no. spp. Solid triangles: number of cytheracean specimens as percentage of total ostracod fauna. Outer horizontal scale refers and is a percentage. c—Number of micro-ostracod specimens as percentage of cytheracean element. d—Number of specimens of *Isocythereis sealensis* as percentage of total ostracod fauna. e—Number of specimens of *Arculicythere tumida* as percentage of total ostracod fauna.

TABLE 7
Characteristic benthic foraminifera from cores 26 to 16 at DSDP site 327 (after Scheibnerova 1981).

Discorbis sp.
Pseudopatellinella howchini
Osangularia utaturensis
Anomalina indica
Gavelinella intermedia
Lingulogavelinella sp.
L. frankei africana
Orithostella indica
Pseudolamarckina sp.
Reinholdella claytonensis
Hoeglundina australiensis
*Rotaliatina asiatica***
*Hergottella jonesi***

** only in cores 20 to 16.

mostly small species belonging to the subfamily Cytherurinae (*Cytherura, Eucytherura, Cytheropteron, Hemingwayella (Parahemingwayella), Hemiparacytheridea, Pedicythere)* (Table 8) but others (*Collisarboris?* and *Aitkenicythere?*) belong to different higher taxa, and Figures 37c–d and 39(c) express these trends as: Cytherurinae as percentage of cytheraceans; micro-ostracods as percentage of total ostracods; and micro-ostracods as percentage of cytheraceans, respectively. From Figure 37 it can be seen that micro-ostracods constitute an important component of the total ostracod population in the lower parts of the sequence (*c.* 15–20%), but that higher up they are less numerous (*c.* 5–10%). A similar trend is shown in Figure 39, where the percentage of the cytheracean component shows erratic high and low values (0–65%) below core 16, and steadier values of 25% or less higher up. This suggest that in cores 21–17 palaeoenvironments conducive to micro-ostracod colonization fluctuated from highly suitable to completely unsuitable, whereas in cores 16–15 conditions were moderately suitable. The smoothed Cytherurinae curve (Fig. 37c) shows that the consistently most suitable conditions occurred during the deposition of core 16. We suggest that these trends could indicate an early period (early–middle Albian) during which palaeoenvironments fluctuated from 'hostile' (possibly restricted circulation, or even mildly anoxic, i.e. no micro-ostracods) to 'somewhat hostile' (abundant micro-ostracods), and that these passed upwards (middle–late Albian) into palaeoenvironments that were more suitable to other cytheraceans (such as *Isocythereis*) and supported only small micro-ostracod populations. Such fluctuations may have been affected by changing palaeogeographies and incursions of water from the isolated South Atlantic basin where Bolli *et al.* (1978) reported dwarf molluscs and sparse arenaceous foraminiferal faunas of Lower to Middle Albian age in the deep-water Cape Basin to the north of the Falkland Plateau.

To summarize, it is postulated that the ostracod populations of samples 2 to 6 (cores 21 to 16, which coincide with the occurrence of *Bairdoppilata* sp. 2) were deposited in water depths of about 200 m, with sample 1 (base of core 21,

TABLE 8
Distribution of Cytheruridae in the Falkland Plateau DSDP 327 and 330 samples
(% total ostracods)

DSDP site nos.	330			327									
Informal samples nos.	1	2	3	1	2	3	4	5	6	7	8	9	
Cytherura? oertlii						5—	—	—	—	—	—	—2	m
Eucytherura rugosa		1											m
E. stellifera					8								m
Procytherura cf. *dinglei*									3				
P. batei	3									18			
Cytheropteron bispinosa		13—	—10				3—	—	—	—6—	—3		m
Indet. sp. 327/18(?)							3						
H. (Parahemingwayella) barkeri		3								3			m
H. (P.) dalzieli		10—	—6										m
H. (P.) reticulata		3—	—1										m
Hemiparacytheridea ewingensis		2											m
H. challengeri		1											m
Pedicythere falklandensis		1—	—1										m
% total ostracods	3	34	18	—	8	5	6	—	3	27	3	2	
% cytheraceans (raw)	7	44	41	—	13	26	16	—	20	69	20	4	
% cytheraceans (smooth)				7	13	18	14	12	30	36	31	12	

m = micro-ostracods
(?) = taxonomic position in family uncertain

early Albian) probably in somewhat shallower water (100–200 m), and sample 7 (middle of core 16, top part of middle Albian) possibly somewhat deeper water (?500 m). Samples 8 and 9 (uppermost middle Albian and late Albian) suggest a return to water depths of about 200 m. Restricted bottom circulation (possibly accompanied by mildly anoxic conditions) may have occurred at the levels of samples 1 to 5 (bottom part of the middle Albian). The energy of sedimentary environments was low throughout the Albian section.

Biostratigraphy

Figure 37 and Tables 6 and 9 show the vertical distribution of Albian ostracod species at DSDP sites 327 and 330. Because of the limited range covered by the samples from 330, the distribution of the eight species restricted to it cannot be assessed: *Pedicythere falklandensis, Eucytherura rugosa, H. (Parahemingwayella) dalzieli, H. (P.) reticulata, Hemiparacytheridea ewingensis, H. challengeri, Asciocythere? dubia*, and indet. sp. 330/1.

At site 327, the nine fossiliferous samples available probably cover most of the Albian and, despite the small numbers of specimens recovered, certain trends are evident. Because of the relatively large numbers of *Robsoniella falklandensis*, the early to late Albian ostracod populations of site 327 are bairdiacian-dominant. The cytheracean element, on the other hand, is quite diverse (fourteen genera, twenty-one species) although certain taxa (e.g. *Arculicythere tumida*, and *Isocythereis sealensis*) locally constitute up to 30% of this component.

Within the Cytheracea various higher taxa are unevenly distributed both in time and in lower taxonomic categories. The Cytherurinae show the greatest diversity (seven genera and thirteen species), and locally are numerically dominant, whereas the Trachyleberidinae is represented by one species only *(Isocythereis sealensis)*, and the Progonocytheridae by two species *(Majungaella?* sp. 327/16 and *Arculicythere tumida)*.

The diversity, local abundance, and small size of representatives of the subfamily Cytherurinae is one of the characteristics of the Albian strata of sites 327 and 330, particularly the dominance of micro-ostracods (*c.* 0,45 mm or less in length) (Table 8). This is particularly so at site 330 (core 1/cc) and site 327 (core 21–3), where 38% and 39%, respectively of the total ostracod population falls into this category. Some of the species occur at one horizon only, while others are found at several levels, where they locally make up a disproportionately large percentage of the total ostracod fauna: *Aitkenicythere? striosulcata*—31% in 327:21–3; *Cytheropteron bispinosa*—13% in 330:1/cc; and *Hemingwayella (Parahemingwayella) dalzieli*—10% in 330:1/cc. Despite the diversity of the micro-ostracods (11 out of 14 species belong to the Cytherurinae), with 9 species in 330 and 8 species in 327, only 3 species from a total of 14 (i.e. 21%) are common to both sites. Similarly, from the 8 genera involved, only 4 are common to the two sites, with *Pedicythere* and *Hemiparacytheridea* restricted to site 330, and *Collisarboris?* and *Cytherura?* restricted to site 327. All four of the last-named genera are widely distributed in the Northern Hemisphere, as well as Australia, so their restriction to either of the DSDP sites must be the result of chance sampling or subtle palaeoenvironmental differences.

The essential biostratigraphic features of the Albian ostracod fauna at site 327 can be summarized:

1. Numerous species of locally short-ranging, but frequently abundant micro-ostracods (overwhelmingly cytherurids).
2. Four long-ranging, numerically abundant species, three of which are widely distributed in mid-Cretaceous Gondwanide sediments: *Arculicythere tumida, Isocythereis sealensis, Robsoniella falklandensis,* and *Cytherella bensoni*. The first two in this list will probably turn out to be useful age diagnostic taxa, and further comment will be made when a comparison is made between the various regions under review.

A breakdown of the temporal distribution of the minor taxa is summarized in Figure 37 and Table 9. These show that two species are restricted to the early Albian, and eleven to the middle Albian, with the remainder ranging middle to late, and early to middle Albian. These ranges cannot be absolute, however, because, for example *Cytheropteron bispinosa* (middle Albian) occurs in core 1 at site 330, as does *Aitkenicythere? striosulcata* (early Albian only at 327). In this category, two species only are known from another area of Gondwanaland, *Aitkenicythere?* sp. 327/18 and *Cytherura? oertlii*, both of which occur off north-western Australia.

Table 9
Ranges of ostracods in DSDP 327.

Restricted to:		
late Albian	— none	
middle Albian	— *Majungaella?* 327/16	(14)
	Procytherura batei	(25)
	P. cf. *dinglei*	(26)
	Pariceratina liebaui	(29)
	H. (Parahemingwayella) barkeri	(33)
	Cytheropteron bispinosa	(40)
	C. sp. 327/18	(41)
	Aitkenicythere? sp. 327/18	(43)
	Indet. sp. 327/16A	(49)
	Indet. sp. 327/18	(50)
	Indet. sp. 327/16B	(51)
early Albian	— *Eucytherura stellifera*	(32)
	Aitkenicythere? striosulcata	(44)
middle to late Albian	— *Isocythereis sealensis*	(16)
	Collisarboris? stanleyensis	(38)
	Cytherura? oertlii	(45)
early to middle Albian	— *Bairdoppilata* sp. 2	(7)

Numbers in right-hand column refer to species numbers in Table 5.

SOUTH-EAST AFRICA

Twenty-five species belonging to sixteen genera (with two species unallocated) have been recorded from the Aptian to Cenomanian strata of south-east Africa. The bulk of these (nineteen species in thirteen genera) are from the Zululand area, where relatively large numbers of specimens were collected from rocks that range in age from Aptian to Cenomanian. Collections from the Outeniqua Basin consist of two samples only (TBD 1113 and 1266), which probably have a range restricted to Upper Aptian–Albian. One species only (*Sondagella theloides*) is common to these two areas in mid-Cretaceous material, although a further two species (*Majungaella nematis* and *M? hemigymnae*) are common in pre-Aptian strata. The distribution of these faunas is shown in Tables 5 and 10.

ZULULAND

Palaeoecology

In Zululand a total of 21 samples yielded ostracods, but because some of these faunas were too small to handle on a CCBC diagram, populations from individual ammonite stages were summed (Table 10) before plotting on Figure 38. The resultant small number of data points, based on disparate numbers of samples, gives rise to two alternative plots depending on whether raw or smoothed data are used. The latter type have usually proved most successful in previous studies (Dingle 1980, 1981), but are probably less suitable in the present case because the populations have already been summed once to provide the stage assemblages. Both alternatives are shown in Figures 38 and 40.

Using smoothed data, the earliest populations (Aptian IV) lie within the field predicting water depths of 100–200 m (the 4a populations of Dingle 1981, figs 68 and 75). This plots as the deepest water population encountered in the Zululand mid-Cretaceous, and younger populations suggest progressively shallower water depths and higher energies of the sedimentary environments: Albian III and Albian IV populations lie above the 'Cytheracea line' and just within the <100 m predictive field; and the Albian IV and Cenomanian II and III populations lie within the high-energy sector of the <100 m predictive field (Dingle 1980, fig. 33; 1981, fig. 75).

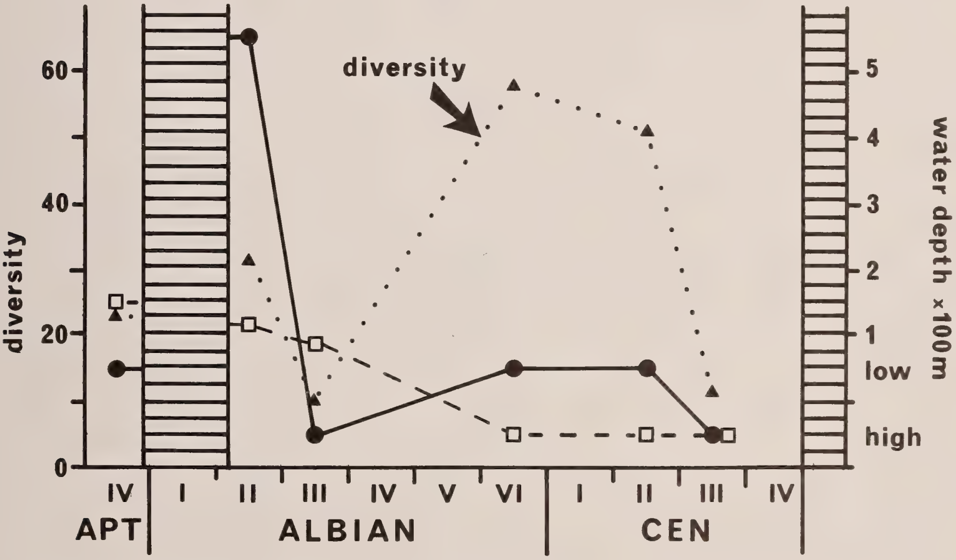

Fig. 40. Predictive water depths for mid-Cretaceous stages in Zululand. Based on the CCBC triangular diagram in Figure 38. Open squares—smoothed data (3 point mean); solid circles—raw data. Water depths <100 m are differentiated into high- and low-energy environments (as defined by Dingle 1980, fig. 33B). Faunal diversity of ostracod populations (raw data) is shown in solid triangles as a percentage (number of species per 100 specimens). Note that Albian I strata are missing at outcrop where the Makatini Formation is unconformably overlain by the Mzinene Formation. Non-sequences shown as horizontal ruling.

Using raw data, on the other hand, the Aptian IV population lies within the low-energy sector of the <100 m water-depth field, while Albian II assemblages, which appeared after the late Aptian to Albian I hiatus, plot within the upper part of the >500 m water depth field. A relatively rapid change to shallow-water (<100 m), high-energy environments is suggested by the Albian III populations, and a further change to low-energy shallow-water (<100 m) conditions is indicated by the Albian VI data point on the Cytheracea–Bairdiacia+Cypridacea

TABLE 10
Mid-Cretaceous ostracods of south-east Africa

(a) Distribution of ostracods in mid-Cretaceous of Zululand (% total fauna)

	Barr	Aptian				Albian					Cenomanian				
Ammonite zones (Kennedy & Klinger 1975)		I	II	III	IV	II	III	IV	V	VI	I	II	III	IV	
Sample nos.				1	2	3	4			5		6	7		Sp. no.
Indet. sp. 1				x											46
Pirileberis makatiniensis					4		9								19
Paracypris sp.					6	55	2			25			8		8
Indet sp. 2					6										47
Cytherella sp.					4	19	16					20	8		2
Pirileberis mkuzensis					8		22								20
Makatinella inflata					4		30								21
Majungaella nematis					13		2					10			12
M? hemigymnae					2										13
Pongolacythere striata					21		1								23
Bairdoppilata sp. 1					8										6
Makatinella tritumida					6	9	3					10	16		22
Cytherelloidea makatiniensis					2		2								4
Procytherura cf. *aerodynamica*					2										24
**Sondagella theloides*							12								10

Cytherelloidea ndumuensis						20		5
Indet cytheraceans		4						
Indet smooth forms		3	18	3	13	10		
No. valves	2	53	11	117	8	10	25	19 spp. 13 gen.

(b) Agulhas Bank area (Outeniqua Basin)

Sample TBD 1113 (Middle–Upper Albian)		Sample TBD 1266 (Upper Aptian–Albian)		
Arculicythere tumida	46%	*Cytherelloidea agulhasensis*	lv	
**Sondagella theloides*	45%	*Cythereis agulhasensis*	lv	
Isocythereis sealensis	5%	*Majungaella* cf. *queenslandensis*	lv	
Majungaella cf. *queenslandensis*	3%			
Cytheropteron? sp.	1%			
No. valves =	92	No. valves =	3	7 spp, 7 gen.
* common to Outeniqua Basin and Zululand				
				25 spp, 16 gen.

(c) Similarity in Zululand

Aptian 14 spp. 11 gen.
Albian 13 spp. 11 gen. } 18 spp., 9 common = 50%
Cenomanian 6 spp, 6 gen. } 14 spp., 5 common = 30%

TABLE 10
Mid-Cretaceous ostracods of south-east Africa

(a) Distribution of ostracods in mid-Cretaceous of Zululand (% total fauna)

	Barr	Aptian				Albian					Cenomanian				
Ammonite zones (Kennedy & Klinger 1975)		I	II	III	IV	II	III	IV	V	VI	I	II	III	IV	
Sample nos.				1	2	3	4			5		6	7		Sp. no.
Indet. sp. 1				x											46
Pirileberis makatiniensis					4	—	9								19
Paracypris sp.					6	55	2	—	—	25	—	—	8		8
Indet sp. 2					6										47
Cytherella sp.					4	19	16	—	—	—	—	20	8		2
Pirileberis mkuzensis					8	—	22								20
Makatinella inflata					4	—	30								21
Majungaella nematis	—	—	—	—	13	—	2	—	—	—	—	10			12
M? hemigymnae	—	—	—	—	2										13
Pongolacythere striata					21	—	1								23
Bairdoppilata sp. 1					8										6
Makatinella tritumida					6	9	3	—	—	—	—	10	16		22
Cytherelloidea makatiniensis					2	—	2								4
Procytherura cf. *aerodynamica*					2										24
**Sondagella theloides*	—	—	—	—	—	—	12								10
Sphaeroleberis? sp. A							3	—	—	13					27
Monoceratina? sp.										13					28
Isocythereis? ndumuensis										38	—	30	68		17
Cytherelloidea ndumuensis												20			5
Indet cytheraceans					4										
Indet smooth forms					3	18	3			13		10			
No. valves				2	53	11	117			8		10	25		19 spp. 13 gen.

(b) Agulhas Bank area (Outeniqua Basin)

Sample TBD 1113 (Middle–Upper Albian)		Sample TBD 1266 (Upper Aptian–Albian)		
Arculicythere tumida	46%	*Cytherelloidea agulhasensis*	lv	
**Sondagella theloides*	45%	*Cythereis agulhasensis*	lv	
Isocythereis sealensis	5%	*Majungaella* cf. *queenslandensis*	lv	
Majungaella cf. *queenslandensis*	3%			
Cytheropteron? sp.	1%			
No. valves	= 92	No. valves	= 3	7 spp, 7 gen.
				25 spp, 16 gen.

* common to Outeniqua Basin and Zululand

(c) Similarity in Zululand

Aptian 14 spp. 11 gen. Albian 13 spp. 11 gen.	18 spp., 9 common = 50%
Albian 13 spp. 11 gen. Cenomanian 6 spp, 6 gen.	14 spp., 5 common = 30%

base line. A deepening and increase in environmental energy is suggested for the Cenomanian II populations that lie close to the predictive 100 m water-depth line, while a shallow-water (<100 m), high-energy environment is indicated by the Cenomanian III population. Figure 40 summarizes the water-depth predictions from these two data sets, and shows that the most substantial difference is the water depth of Albian II deposition following the hiatus that separates the Makatini and Mzinene formations. With the exception of this point on the 'raw data' plot, and the Aptian IV point on the 'smoothed data' plot, all other points lie within the field predictive of water depths (<100 m), although there is disparity in assessing environmental energy.

In summary, we suspect that the depositional environments of all the stages shown in Figure 40, with the exception of Albian II, were in water depths of <100 m, with that of the Cenomanian III, at least, in relatively high-energy conditions prior to the commencement of the local Cenomanian IV to Coniacian hiatus. The Albian II populations, which re-colonized the area after the late Aptian to early Albian hiatus, were probably dominated by *Cytherella* and *Paracypris*, and suggest water depths in excess of 200 m (the value of >500 m indicated by one data set on the CCBC diagram may be biased because of the small assemblage available for study).

Table 11 shows some of the population characteristics of the mid-Cretaceous strata of Zululand, and it is significant that, except in Albian II, cytheraceans invariably comprise the dominant (>20%) elements in the assemblage, and in particular that *Isocythereis? ndumuensis* is a dominant species for Albian VI to Cenomanian III time. A further point to note is the relatively low faunal diversity suggested for Albian III and Cenomanian III assemblages, both of which are predicted to lie in the higher-energy shallow-water field of the CCBC diagram (Fig. 38, 'raw data' plot).

Biostratigraphy

The temporal ranges of ostracods found in the Zululand mid-Cretaceous rocks are shown in Tables 1, 10, and 12. In the cytheracean components two groups can be distinguished: those that are known only from Zululand, and those that have been recorded from other localities in south-east Africa and Gondwanaland. The latter comprises *Majungaella nematis* and *Sondagella theloides*, which range upwards into Cenomanian II and Albian III, respectively. These are the youngest records of the two species, both of which have extensive temporal and spatial ranges outside the south-east African region.

Faunal diversity in the various stages is shown in Table 11, but some of the values are probably not meaningful because of the small numbers of specimens involved in certain samples, in particular the high diversity recorded for Albian VI and Cenomanian II. An aspect that is probably significant is the similarity and relatively high diversity in the Aptian IV and Albian II populations, where there are several apparently short-range cytheracean taxa such as *Makatinella inflata*, *Pongolacythere striata*, and two species of *Pirileberis* (*makatiniensis* and

TABLE 11

Population characteristics and suggested palaeoenvironments, mid-Cretaceous of Zululand.

	Aptian IV	Albian II	Albian III	Albian VI	Cenomanian II	Cenomanian III
dominant >20 %	*P. striata*	*Paracypris* sp.	*P. mkuzensis* *M. inflata*	*I? ndumuensis* *Paracypris* sp.	*I? ndumuensis* *Cytherella* sp. *C. ndumuensis*	*I?ndumuensis*
secondary >10 %	*M. nematis*	*Cytherella* sp.	*Cytherella* sp. *S. theloides*			*M. tritumida*
tertiary >5 %	*P. mkuzensis* *M. tritumida*	*M. tritumida*	*P. makatiniensis*			
suggested palaeo-environments	shallow water, <100 m	moderate to deep water, ?>200 m	shallow water, <100 m	shallow water, <100 m	shallow water, <100 m	shallow water, <100 m, high energy
faunal diversity (no. spp./ 100 spec.)	32 %	32 %	10 %	63 %	56 %	16 %

TABLE 12

Temporal distribution of mid-Cretaceous cytheracean ostracods from Zululand.

(a) Confined to Aptian:
- Indet. sp. 1
- Indet. sp. 2
- *Majungaella ?hemigymnae*
- *Procytherura* cf. *aerodynamica*

(b) Confined to Albian:
- *Sphaeroleberis?* sp.
- *Monoceratina?* sp.

(c) Confined to Cenomanian:
- *Cytherelloidea ndumuensis*

(d) Confined to Mzinene Formation (Albian–Cenomanian):
- *Sphaeroleberis?* sp.
- *Monoceratina?* sp.
- *Isocythereis? ndumuensis*
- *Cytherelloidea ndumuensis*

mkuzensis). It appears that despite the hiatus between the Makatini and Mzinene formations (Albian I is missing), there was faunal continuity in the ostracod populations across the Aptian–Albian boundary. This is shown by a 50 per cent similarity level in all ostracod taxa between Aptian and Albian strata (Table 10). In contrast our evidence, although slender, does point to the establishment, by at least the end of Albian III times, of an Albian–Cenomanian assemblage whose most diagnostic element so far recognized is *Isocythereis? ndumuensis*. A similarity index of only 36 per cent is found in the total fauna between the Albian and Cenomanian strata (Table 10). *Makatinella tritumida*, an easily recognized taxon, is the only member of the endemic cytheracean group known to range from Aptian IV to Cenomanian III. From these Zululand mid-

Cretaceous ostracod populations no species is known to extend into the overlying St. Lucia Formation (Coniacian at outcrop, Turonian at subcrop), indicating a major faunal discontinuity between the mid-Cretaceous and Upper Cretaceous strata.

OUTENIQUA BASIN

Of the two samples from the Agulhas Bank, only TBD 1113 contains a large ostracod fauna (ninety-two valves), and this is composed entirely of cytheracean types, with *Arculicythere tumida* (46%) and *Sondagella theloides* (45%) the dominant taxa (Table 10). We have no other similar populations with which to make a comparison, and the known environmental preferences of the two dominant taxa appear to be at variance. *Arculicythere tumida* occurs in DSDP 259, 327 and 330, and in all cases was probably deposited in water depths of *c*. 200 m, whereas previous records of *Sondagella theloides* have been from strata that were probably deposited in relatively shallow, near-shore conditions (e.g. Algoa Basin where arenaceous foraminifera, wood fragments, and ostreids are common (Brenner & Oertli 1976)). Their mutual presence in sample TBD 1113 may indicate that each species was near the limit of its own environmental tolerance, but the anomalous aspect of this conclusion is that both occur in relatively large numbers. The fact that *Isocythereis sealensis* also occurs in DSDP 327 in samples that suggest deposition in water depths of *c*. 200 m (where it makes up 3 to 14% of the fauna), and is present in small numbers (5%) in TBD 1113, indicates that it is probably *Sondagella theloides* that has a greater water depth tolerance than previously suspected.

REGIONAL CONSIDERATIONS

During the time interval with which we are concerned, the palaeogeography of this part of Gondwanaland underwent significant changes. Reconstructions are shown in Figure 42 (a and b) (pre-breakup Valanginian, and middle Albian–Cenomanian, respectively). It is essential to consider the regional spatial and temporal distribution of the various taxa in terms of these palaeogeographies because they change from essentially intercontinental shelf seas (pre-breakup) to continental margin seas separated by deep ocean basins (Cenomanian). In addition, it must be borne in mind that there was no connection between the north and south sectors of the Atlantic Ocean across the Walvis Ridge before late Cenomanian–early Turonian times, and that the mid-Cretaceous ostracod populations with which we are concerned can be seen as the last representatives of an Upper Jurassic to Cenomanian ostracod faunal province within South Gondwanaland seas (Dingle 1982; Tambareau 1982). Figure 41 is a range chart for mid-Cretaceous ostracods that are common to more than one of the regions in Figure 42, or have close relatives elsewhere in South Gondwanaland.

Dingle (1982) has given details of the whole pre-Aptian South Gondwanaland ostracod fauna, but here it is relevant to emphasize the distribution of two

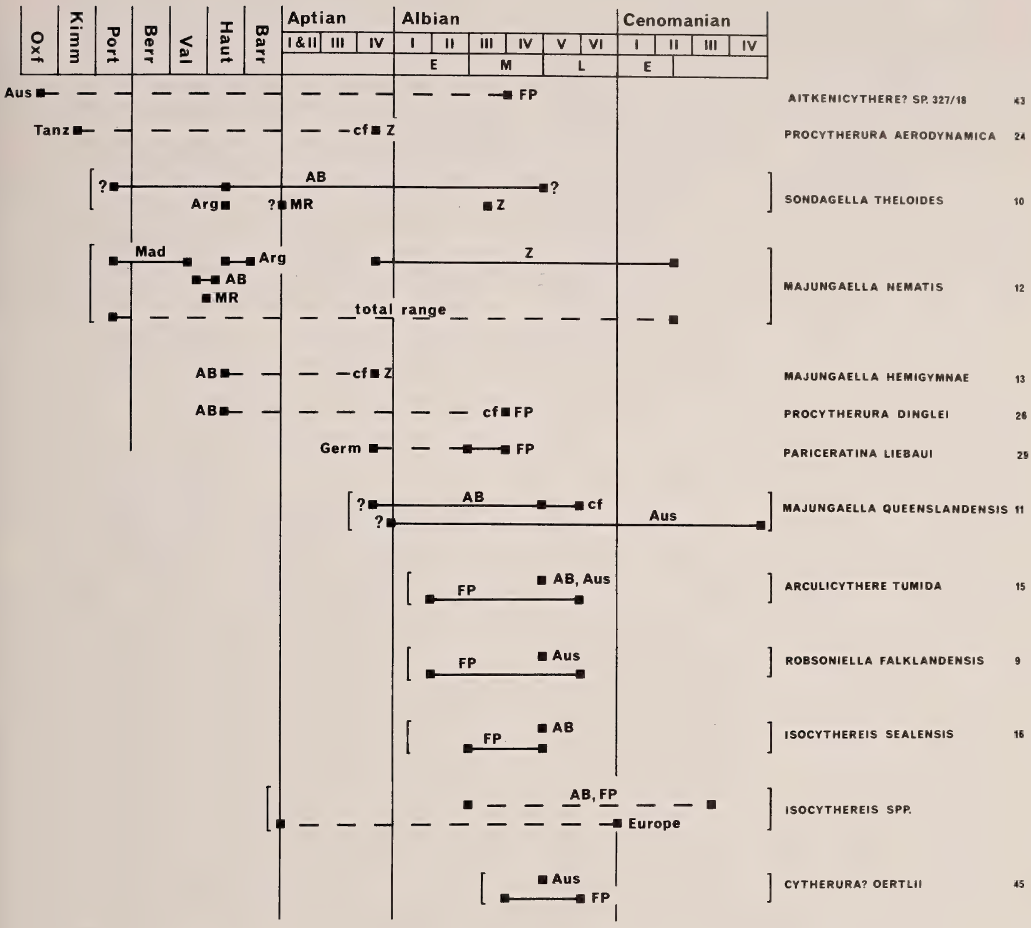

Fig. 41. Spatial and temporal distribution of selected species of ostracods in the mid-Cretaceous of south-east Africa and the Falkland Plateau, and adjacent Gondwanide localities. For comparison some distributions in more distant areas and pre mid-Cretaceous horizons are also noted. Dashed lines show total range from different geographical localities, solid lines are total ranges within one locality. Numbers on right-hand side are informal sample numbers used in Table 5. The Aptian to Cenomanian stages are those of Kennedy & Klinger (1975), and correlation with early, middle, and late subdivisions of DSDP (Barker *et al.* 1977) are nominal. See text for range citations. Abbreviations: Aus—Australia; FP—Falkland Plateau; Tanz—Tanzania; Z—Zululand; AB—Agulhas Bank, Arg—Argentina; MR—Mozambique Ridge; Mad—Madagascar; Germ.—Germany.

important species in terms of a pre-drift Valanginian palaeogeography (Fig. 42a). In this reconstruction, which is meant to illustrate the period immediately prior to, and immediately after, drifting in the Natal Valley–South Atlantic, conditions of no sedimentation or very slow anoxic sedimentation obtained over the DSDP sites (327 and 330) of the southern Maurice Ewing Bank: no ostracods were recovered from the Kimmeridgian–Aptian condensed sequences (or non-sequences) developed during this period. However, because the Agulhas Bank, Mozambique Ridge (DSDP 249), and Madagascar (Majunga Basin) are all characterized by the presence of *Majungaella nematis*, a shallow sea-way must have bypassed the Maurice Ewing Bank on its southern and, possibly, northern flanks. The latter route is suggested by the presence of marine strata of suspected Valanginian–Hauterivian age on the Transkei coast at Mngazana (McLachlan *et al.* 1976*a*). The Zululand–South Mozambique region lay to the west of the coastline at this time because pre-Upper Barremian marine sediments are unknown from the area.

Majungaella nematis also occurs in Hauterivian sediments in the Neuquen Basin of west central Argentina (Figs 1, 42a), which, with the presence of *Sondagella theloides*, indicates a connection with the Agulhas Bank area. Whether this connection actually lay across the site of the present South Atlantic (for which no subsurface structural evidence has been found, but which seems the most obvious route), or via an east Pacific to south-western Indian Ocean route (there is a western exit to the Neuquen Basin), is not known. *M. nematis* also occurs on the Mozambique Ridge (DSDP site 249) and in Madagascar, giving a geographical range of at least 6 500 km. Faunal continuity across western South Gondwanaland at the time of initial continental drifting between southern Africa and South America is, therefore, an established element in the pre-mid-Cretaceous palaeogeography. This conclusion is at variance with that reached by Jones & Plafker (1977) who studied the Mesozoic molluscs from DSDP sites 327 and 330 on the Falkland Plateau. On the basis of the presence of bivalves such

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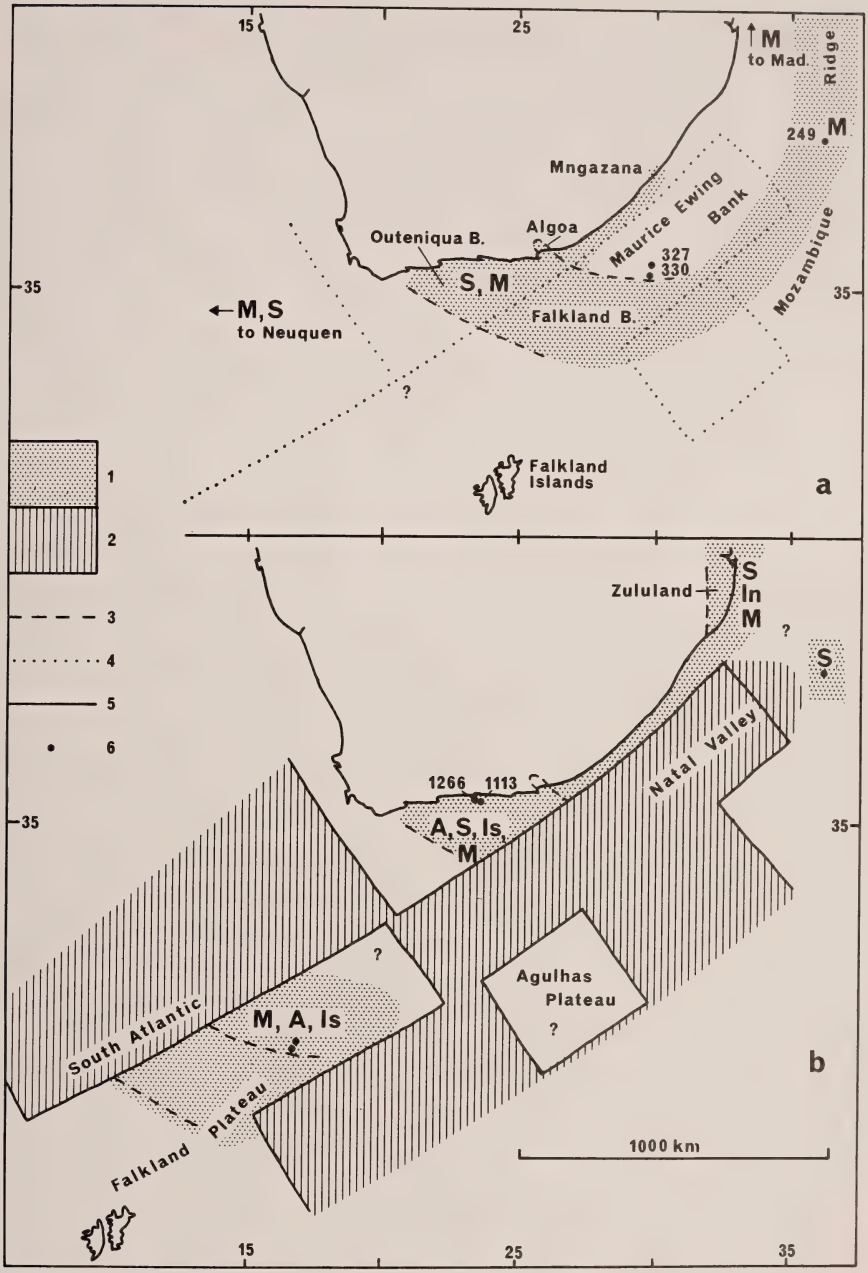
Fig. 42. Mid-Cretaceous palaeogeographies and ostracod distribution in south-east Africa and the Falkland Plateau. Refits are based on Dingle & Scrutton (1974), Tucholke *et al.* (1981), Scrutton (1976), Martin *el al.* (1981), Dingle *et al.* (1983). a. Pre-drift palaeogeography (Valanginian). Ostracod distributions relate to pre- (Valanginian) and earliest- (Hauterivian) drift times. The extension of shallow marine conditions north-west of the Maurice Ewing Bank are suggested by the occurrence of ?Valanginian ostracods at Mngazana on the Transkei coast (McLachlan *et al.* 1976*a*). b. Early Cenomanian palaeogeography (say 99 m.y.). Ostracod distributions relate to mid-Albian to early Cenomanian times (except *Sondagella theloides* on the Mozambique Ridge, recorded in early Aptian or Barremian).

Key: 1—shallow marine conditions on continental crust; 2—deep water conditions on oceanic crust; 3—boundaries of Outeniqua–Falkland Basin (probably faulted); 4—lines of subsequent continental separation; 5—continental edges; 6—sampling sites, 249 DSDP leg 25, 327 and 330 DSDP leg 36, 1113 and 1266 dredge sites on Agulhas Bank.

Abbreviations: M—*Majungaella* spp. (all *M. nematis* except *M?* sp. 327/16 on Falkland Plateau and *M.* cf. *queenslandensis* in the Outeniqua Basin in (b)); S—*Sondagella theloides*; A—*Arculicythere tumida*; Is—*Isocythereis sealenis*; In—*Isocythereis? ndumuensis*. Mad—Madagascar, B—Basin. Faunal data from numerous references cited in the text.


15
25
M
to Mad.
Ridge
249
M
Mngazana
Maurice Ewing
Bank
Outeniqua B.
Algoa
327
330
S, M
35
35
Mozambique
M, S
to Neuquen
Falkland B.
?
Falkland
Islands
a
1
2
3
4
5
6
Zululand
S
In
M
?
S
Natal Valley
1266
1113
A, S, Is,
M
35
35
?
South Atlantic
M, A, Is
Agulhas
Plateau
?
b
Falkland
Plateau
1000 km
15
25
35

as *Aucellina* and *Malayomaorica*, these workers faunally linked the Jurassic and Lower Cretaceous Falkland Plateau with austral sites in the East Indies, Australasia and Pacific South America, and drew a distinction between them and the Tethyan faunas of south-east Africa and Madagascar. To account for this apparent anomaly they suggested that either the Falkland Plateau did not originally lie off south-east Africa, or that the two areas were separated by a land or oceanographic barrier. We believe that studies such as those by Norton & Sclater (1979) and Martin *et al.* (1981) have firmly established the relative palaeoposition of the Falkland Plateau, and that the remaining disparity may be caused by our lack of knowledge of south-east African Jurassic and Lower Cretaceous bivalves, which await modern taxonomic revision. Certainly, our study of the benthic ostracods do not lend support to Jones & Plafker's main conclusions.

The post-drift palaeogeography shown in Figure 42b is designed to illustrate the situation immediately following continental separation between the Falkland Plateau and the Agulhas Bank (latest Albian), whilst faunal details shown at the various sites cover the period mid-Albian (Albian III) to early Cenomanian. By the beginning of this period, anoxic conditions over the Falkland Plateau DSDP sites and in the deep parts of the narrow South Atlantic basin had largely been dispelled, and marine ostracod faunas had become established, at least in the former area. During the period covered by Figure 42b, final continental separation between southern Africa and the Falkland Plateau (i.e. South America) took place, and after about 100 m.y. (latest Albian) no shallow-water (continental shelf depth) connections persisted between the two areas. As sea-floor spreading proceeded, the gap between the two areas progressively increased, presumably preventing any further contact between elements in ostracod populations that were adapted solely to shallow-water environments.

MID-CRETACEOUS FAUNAL LINKS BETWEEN SOUTH-EAST AFRICA AND THE FALKLAND PLATEAU

Mid-Cretaceous faunal relationships are summarized in Table 13 and Figure 42b. Localities from which data are available are different to those shown in the pre-drift palaeogeography: no marine sediments of Barremian to Lower Maastrichtian age are known from the Neuquen Basin, while in mid-Cretaceous times, marine sedimentation commenced in Zululand and recommenced on the Maurice Ewing Bank. *Sondagella theloides* occurs in the Outeniqua Basin and in Zululand, but appears not to have spread to the eastern Falkland Plateau when normal marine conditions became re-established in early Albian times, even though it originally extended westward into the Neuquen Basin, and has been recorded from the Mozambique Ridge (DSDP 249). Its known upper limit is Albian III (in Zululand) (Fig. 41). The genus *Majungaella*, on the other hand, did migrate into the Falkland Plateau area, presumably from the Outeniqua Basin which lay adjacent to it in middle Albian times. *Majungaella nematis* is known to extend into the Cenomanian in Zululand, but only rare specimens of related species are known from Albian strata of the Outeniqua Basin *(M.* cf.

TABLE 13
Summary of faunal links.

(a) South-east Africa and the Falkland Plateau	
primary links	
Sondagella theloides	OB–Z–N*
Majungaella nematis	OB*–Z–N*–M*
Arculicythere tumida	OB–FP–Au
Isocythereis sealensis	OB–FP
I? ndumuensis	Z
Robsoniella falklandensis	FP–Au
Pirileberis spp.	Z–M
secondary links	
Aitkenicythere? spp.	FP with U.Jur. Au, T
Procytherura cf. *aerodynamica*	Z with Kimm. T
P. cf. *dinglei*	FP with Haut/Val. OB
P. batei	FP similar to *P. maculata* from Haut. OB
	FP similar to *Paijenborchellina* sp. 1 (Damotte)
Cytherura? oertlii	FP with Alb. Au
(b) Between Zululand, Madagascar, Tanzania	
Pirileberis	Z–T–M
Pongolacythere	Z similar to T

Abbreviations:
OB = Outeniqua Basin (Agulhas Bank + Algoa), Z = Zululand, FP = Falkland Plateau, N = Neuquen, Au = Australia, M = Madagascar, T = Tanzania, U.Jur. = Upper Jurassic, Kimm = Kimmeridgian, Haut = Hauterivian, Val = Valanginian, Alb = Albian.

*pre-Albian occurrences

queenslandensis) and the Falkland Plateau *(Majungaella?* sp. 327/16*)*. The genus was clearly on the wane in this part of Gondwanaland, because in all localities it forms only a minor component of the fauna. In this situation, *Sondagella* and *Majungaella* represent residual elements of the late Jurassic–Lower Cretaceous faunas of South Gondwanaland that had been geographically very extensive (see Dingle 1982).

New elements which did vigorously take advantage of the radical and evolving palaeogeographic dispensation were the genera *Isocythereis* and *Arculicythere*. Presumably because of newly established circulation patterns and the resultant environmental disparities, the faunas of Zululand and the Outeniqua Basin show only weak links in these new taxa, whereas the latter and the Falkland Plateau, which were still physically joined in Albian times (although possibly bathymetrically separated by the shallow or emergent region of the Agulhas Arch–Maurice Ewing Bank), have close links at species level. The genus *Isocythereis* is represented by *I. sealensis* in the Outeniqua Basin and Falkland Plateau, and by *I? ndumuensis* in Zululand. These two species are not closely related, emphasizing the relative isolation of the two areas. Similarly, *Arculicythere tumida* occurs at the southern two localities but is absent from Zululand. This species is also present in the Albian of DSDP site 259 of western Australia and indicates continuity at shallow to moderate water depths over a distance of at least 6 000 km. *Arculicythere* first appears in the Portlandian to Valanginian of Madagascar. Similar long-range connections between Australia and the Falkland Plateau are indicated by the mutual presence of *Robsoniella falklandensis* and *Cytherura? oertlii* (in the Albian of both areas). The bulk of the cytheracean ostracods which colonized Zululand during the late Barremian transgression do not have relations in either the Outeniqua or Falkland basins, but have closer ties (albeit through Upper Jurassic and Lower Cretaceous relatives) with both Madagascar and Tanzania.

One interesting characteristic of the Falkland Albian assemblages is the relative abundance and diversity of the micro-ostracod populations. Elements of these indicate a connection to the North Atlantic–European areas (e.g. *Pariceratina*, *Eucytherura*, and *Hemiparacytheridea*), which all evidence points to not being via the present-day South Atlantic route but presumably via east Africa and Tethys. The fact that none of these distinctive taxa has been recorded from mid-Cretaceous strata in south-east Africa indicates a subtle, but important, environmental difference between the latter areas and the Falkland Plateau. It was certainly the most 'oceanic' of the three settings that we have investigated, and possibly may also have been affected by poorly oxygenated waters periodically sweeping over the plateau from the South Atlantic basin.

In connection with the Callovian to Cenomanian South Gondwana ostracod province (Dingle 1982) to which reference has previously been made, the following summary can be provided:

1. In pre-Albian times, *Majungaella nematis, Sondagella theloides, Amicytheridea,* and *Progonocythere* were characteristic elements, but no record of these is known from the eastern Falkland Plateau. This we refer to as the 'old' or South Gondwana Fauna A (Table 14).

TABLE 14
Main elements of Mesozoic Gondwana ostracod faunas.

1. South Gondwana Fauna A ('old' faunal elements) (Callovian to Aptian)	
Majungaella nematis	
Sondagella theloides	
Amicytheridea brentonensis	
'Progonocythere' inhopyensis	
'P.' befotkaensis	
'P.' accessa	
Pirileberis progonata	
Rostrocytheridea ornata	
2. South Gondwana Fauna B (mixture of 'old' (o) and 'new' (n) faunal elements) (Albian to Cenomanian)	
Majungaella nematis	(o)
Sondagella theloides	(o)
Arculicythere tumida	(n)
Isocythereis sealensis	(n)
Robsoniella falklandensis	(n)

2. Following the withdrawal of the sea from the Neuquen Basin and the Albian transgression in the Falkland, Outeniqua, and Zululand areas, certain elements of the 'old' fauna colonized Zululand, re-colonized the Outeniqua Basin, but made only a limited penetration of the Falkland Plateau. New taxa appeared with this transgression in all three areas, producing a mixed association of 'old' and 'new' elements that we refer to as South Gondwana Fauna B (Table 14).

3. The South Gondwana Fauna B was relatively short-lived (Albian to Cenomanian) because, following the late Cenomanian–Turonian hiatus that affected most parts of South Gondwanaland, it was totally replaced in the ensuing Turonian–Coniacian transgression by aggressive new shallow-water forms in south and east Africa and India, and by deep-water forms in the Falklands area. Both these assemblages have a cosmopolitan aspect, which display few characters that could be specifically related to a 'Gondwana' location. An equally dramatic change can be seen in the Neuquen Basin when it was inundated again in the Middle Maastrichtian. Here, colonization took place from the north, and its latest Cretaceous and Palaeogene faunas are closely allied to those from Brazil and Equatorial west Africa.

ACKNOWLEDGEMENTS

I gratefully acknowledge the help give by Dr H. C. Klinger of the South African Museum, Cape Town, both as guidance during fieldwork in Zululand in 1977, and for valuable discussions over several years on the Cretaceous stratigraphy of south-east Africa. Deep Sea Drilling Project samples from the Falkland Plateau were kindly made available by the Lamont–Doherty Geological Observatory repository. Mr D. Gerneke and Dr D. Crawford of the University of Cape Town Electron Microscope Unit are thanked for their considerable assistance with photography, and Dr A. R. Lord kindly made available to me the SEM facility in the Micropalaeontology Research Unit at University College, London, during my study leave in 1981. University of Cape Town staff research grants are gratefully acknowledged for fieldwork and SEM expenses. The Editorial Board of the University of Cape Town provided a generous grant towards part of the publication costs for this work. Mrs Grace Krummeck is thanked for typing the manuscript.

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Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family **Nuculanidae**

Nuculana (Lembulus) bicuspidata (Gould, 1845)

Figs 14–15A

Nucula (Leda) bicuspidata Gould, 1845: 37.
Leda plicifera A. Adams, 1856: 50.
Laeda bicuspidata Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).
Nucula largillierti Philippi, 1861: 87.
Leda bicuspidata: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:
comma separates author's name and year
semicolon separates more than one reference by the same author
full stop separates references by different authors
figures of plates are enclosed in parentheses to distinguish them from text-figures
dash, not comma, separates consecutive numbers

Synonymy arrangement according to chronology of bibliographic references, whereby the year is placed in front of each entry, and the synonym repeated in full for each entry, is not acceptable.

In describing new species, one specimen must be designated as the holotype; other specimens mentioned in the original description are to be designated paratypes; additional material not regarded as paratypes should be listed separately. The complete data (registration number, depository, description of specimen, locality, collector, date) of the holotype and paratypes must be recorded, e.g.:

Holotype

SAM–A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach Port Elizabeth (33°51′S 25°39′E), collected by A. Smith, 15 January 1973.

Note standard form of writing South African Museum registration numbers and date.

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Capital initial letters

(a) The Figures, Maps and Tables of the paper when referred to in the text
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e.g. Therocephalia, but therocephalian

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Roman numerals should be converted to arabic, except when forming part of the title of a book or article, such as
'Revision of the Crustacea. Part VIII. The Amphipoda.'

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Name of new genus or species is not to be included in the title: it should be included in the abstract, counter to Recommendation 23 of the Code, to meet the requirements of Biological Abstracts.

R. V. DINGLE

MID-CRETACEOUS OSTRACODA FROM SOUTHERN AFRICA AND THE FALKLAND PLATEAU

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FISCHER, P.-H., DUVAL, M. & RAFFY, A. 1933. Études sur les échanges respiratoires des littorines. *Archs Zool. exp. gén.* **74**: 627–634.
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(continued inside back cover)

ANNALS OF THE SOUTH AFRICAN MUSEUM
ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

Volume **93** Band
June **1984** Junie
Part **4** Deel

THE SOUTH AFRICAN MUSEUM'S *MEIRING NAUDE* CRUISES
PART 15
MARINE ISOPODA OF THE 1977, 1978, 1979 CRUISES

By

BRIAN KENSLEY

Cape Town Kaapstad

The ANNALS OF THE SOUTH AFRICAN MUSEUM

are issued in parts at irregular intervals as material
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Obtainable from the South African Museum, P.O. Box 61, Cape Town 8000

Die ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

word uitgegee in dele op ongereelde tye na gelang van die
beskikbaarheid van stof

Verkrygbaar van die Suid-Afrikaanse Museum, Posbus 61, Kaapstad 8000

OUT OF PRINT/UIT DRUK
1, 2(1–3, 5–8), 3(1–2, 4–5, 8, t.–p.i.), 5(1–3, 5, 7–9),
6(1, t.–p.i.). 7(1–4), 8, 9(1–2, 7), 10(1–3),
11(1–2, 5, 7, t.–p.i.), 14(1–2), 15(4–5), 24(2), 27, 31(1–3), 32(5), 33, 36(2), 45(1)

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Kopieregnavrae aan die Suid-Afrikaanse Museum

ISBN 0 86813 055 9

Printed in South Africa by
The Rustica Press, Pty., Ltd.,
Court Road, Wynberg, Cape

In Suid-Afrika gedruk deur
Die Rustica-pers, Edms., Bpk.,
Courtweg, Wynberg, Kaap

THE SOUTH AFRICAN MUSEUM'S *MEIRING NAUDE* CRUISES

PART 15

MARINE ISOPODA OF THE 1977, 1978, 1979 CRUISES

BY

BRIAN KENSLEY

Smithsonian Institution, Washington, D.C.

(With 43 figures and 1 table)

[*MS accepted 25 August 1983*]

ABSTRACT

Fifty-one species (excluding the Anthuridea) collected off the east coast of South Africa are recorded. Two new genera, *Agularcturus* (Arcturidae) and *Natalianira* (Janiridae) and the following new species are described: *Agularcturus granulatus, Antarcturus bicornis, Astacilla eminentia, Microarcturus barnardi, M. halei, M. longispinus, M. nordenstami, Cirolana bougaardti, C. convexissima, Paracilicaea cordylina, Stenetrium perestrelloi, Ianisera expansa, Natalianira spinosa, Joeropsis integer, J. serrulus, Notoxenoides acalama, Haplomesus zuluensis, Ischnomesus glabra, Stylomesus natalensis*. The new name, *Cirolana anocula*, is provided for *C. caeca* Kensley, 1978, *non* Dollfus, found to be a homonym of a previously described Mediterranean species.

A brief discussion of the distribution and zoogeography of the isopods of all five cruises indicates the presence of a large endemic isopod fauna on the continental shelf and/or slope of the east coast of South Africa.

CONTENTS

PAGE
Introduction 213
Species list for the 1977–9 cruises (excluding Anthuridea) 214
Systematic discussion 217
    Family Arcturidae 217
    Family Cirolanidae 260
    Family Sphaeromatidae 268
    Family Stenetriidae 272
    Family Janiridae 275
    Family Joeropsidae 285
    Family Pleurogoniidae 289
    Family Ischnomesidae 291
Distribution and zoogeography 298
Acknowledgements 299
References 299

INTRODUCTION

The present paper deals with most of the isopod material collected by the South African Museum's *Meiring Naude* cruises of 1977, 1978, and 1979. The isopod material from the first two cruises has already been dealt with in several

Ann. S. Afr. Mus. **93** (4), 1984: 213–301, 43 figs, 1 table.

publications (the Anthuridea (Kensley 1978*c*) and infraorders excluding the Anthuridea (Kensley 1978*a*)). Several shorter papers dealing with discreet taxa have also appeared (Kensley 1978*b*, 1978*d*, 1979). The Anthuridea of the three later cruises have been included in a revision of the southern African fauna (Kensley 1982). A brief discussion of the distributional information of all the cruises is given at page 298. A review of all the southern African species of *Microarcturus* (including those not collected during the *Meiring Naude* cruises) is included in an attempt to clarify the complicated taxonomy of this genus. Because of the confusion over names in the genus *Astacilla*, figures and a brief description of one Mediterranean species is included.

Station data for the 1975 and 1976 cruises may be found in Louw (1977), and for the 1977–9 cruises in Louw (1980).

SPECIES LIST FOR THE 1977–9 CRUISES (EXCLUDING ANTHURIDEA)

Material not identified to specific level is either damaged or immature.

	SM station no.	♂	♀	ovig. ♀	juv.
INFRAORDER VALVIFERA					
Family **Arcturidae**					
**Agularcturus granulatus* sp. nov.	163	3	—	2	3
	179	—	—	1	—
	185	1	—	—	—
**Antarcturus bicornis* sp. nov.	226	—	—	—	1
	232	4	—	—	2
Antarcturus kladophorus Stebbing	185	1	—	—	—
Arcturina hexagonalis Barnard	180	—	3	3	—
Arcturina scutula Kensley	164	1	—	—	—
	179	—	—	1	—
	180	1	—	2	—
Arcturinoides sexpes Kensley	163/4	17	10	18	—
	179	1	1	—	—
	180	5	1	7	—
	185	24	20	53	4
Astacilla corniger (Stebbing)	185	1	1	1	5
**Astacilla eminentia* sp. nov.	103	1	—	—	3
	109	1	—	—	—
	226	2	—	—	—
	232	2	2	—	—
	250	2	—	—	—
Astacilla longispina (Kensley)	250	1	1	—	—
Astacilla tranquilla (Kensley)	163/4	2	—	—	1
	179	1	—	—	—
	185	2	—	—	—
Austroarcturus africana Kensley	163	3	—	2	4
	179	3	—	2	2
	180	21	14	15	12
	185	8	4	10	2

* = new record

	SM station no.	♂	♀	ovig. ♀	juv.
Austroarcturus foveolatus Kensley	163/4	—	—	1	—
	180	1	1	—	1
	185	8	4	2	13
**Microarcturus barnardi* sp. nov.	163	10	—	4	12
Microarcturus dayi Kensley	179	1	—	—	—
	180	6	—	1	4
**Microarcturus halei* sp. nov.	103	11	—	5	—
	109	—	—	1	—
	123	2	—	2	—
	226	11	—	6	20
	232	14	—	4	4
	250	6	—	6	17
**Microarcturus longispinus* sp. nov.	226	—	—	1	—
	228	1	—	—	—
	250	2	—	1	1
**Microarcturus nordenstami* sp. nov.	163	—	—	1	—
	185	13	4	13	9
	226	1	—	—	—
Microarcturus ornatus Kensley	228	5	—	—	—
	236	1	—	—	—
	250	6	—	—	—
Microarcturus oudops (Barnard)	103	2	—	4	4
	129	4	—	2	1
	226	7	—	6	—
	228	5	—	1	—
	236	1	—	—	1
Microarcturus quadriconus Kensley	179	2	—	5	—
	180	8	1	12	22
Microarcturus youngi Kensley	123	1	—	—	—
	129	3	—	—	2
	226	4	—	2	1
	232	14	1	4	—
Spinarcturus natalensis Kensley	123	1	—	—	—
	129	1	2	—	—
	226	—	—	—	1
	250	—	1	—	1
Family **Idoteidae**					
Idotea metallica Bosc	54	1	—	—	—
	160	—	1	—	—
	170	—	—	1	—
INFRAORDER FLABELLIFERA					
Family **Cirolanidae**					
Cirolana anocula nom. nov.	123	—	3	2	3
	129	5	3	5	6
**Cirolana bougaardti* sp. nov.	162	1	—	—	—
	226	1	—	—	—
**Cirolana convexissima* sp. nov.	250	2	—	2	7
Cirolana theleceps Barnard	163	—	1	—	—
	179	—	2	—	—
	185	—	2	—	—
Cirolana virilis Barnard	250	—	1	—	—
Conilorpheus scutifrons Stebbing	185	—	1	—	—
Family **Aegidae**					
Syscenus infelix Harger	119	1	—	—	—

* = new record

	SM station no.	♂	♀	ovig. ♀	juv.
Family **Sphaeromatidae**					
Cymodoce alia Kensley	250	1	1	—	1
Cymodoce tuberculosa Richardson	163	5	—	—	—
Cymodoce velutina Kensley	185	1	1	—	1
	250	—	—	—	1
**Paracilicaea cordylina* sp. nov.	15	1	—	—	—
INFRAORDER GNATHIIDEA					
Family **Gnathiidae**					
Gnathia africana Barnard	179	1	—	—	—
	185	33	7	—	—
Gnathia cryptopais Barnard	226	2	—	—	—
	228	1	—	—	—
	232	2	—	—	—
Gnathia spongicola Barnard (*in situ*, in sponge *Tylodesma* sp.)	86	3	—	—	—
INFRAORDER ASELLOTA					
Family **Stenetriidae**					
Stenetrium abyssale Wolff	165	1	—	—	—
	226	—	1	—	—
Stenetrium crassimanus Barnard	250	—	2	—	—
Stenetrium dagama Barnard	123	1	1	—	—
	129	1	2	1	—
	151	—	1	—	—
	185	—	1	—	—
	226	2	—	—	—
	232	1	—	—	—
Stenetrium diazi Barnard	250	3	—	—	4
**Stenetrium perestrelloi* sp. nov.	163/4	2	1	1	18
Stenetrium saldanha Barnard	185	1	—	—	—
Family **Janiridae**					
**Ianisera expansa* sp. nov.	86	—	2	1	—
	103	—	4	—	—
	123	2	2	—	—
	129	4	3	4	—
	185	—	1	—	3
	226	3	2	1	—
**Natalianira spinosa* sp. nov.	86	1	—	—	—
	103	1	—	—	—
	123	1	—	—	—
	129	1	—	1	—
Paracanthaspidia natalensis Kensley	123	1	—	—	—
	226	—	1	—	—
	228	—	1	1	—
Spinianirella walfishensis Menzies	129	2	6	1	1
	162	—	1	—	—
	226	1	—	—	—
	236	1	—	—	—
	250	—	1	—	—
Family **Joeropsidae**					
**Joeropsis integer* sp. nov.	163	—	2	1	—
**Joeropsis serrulus* sp. nov.	163/4	—	1	1	—
	185	—	—	1	—

* = new record

	SM station no.	♂	♀	ovig. ♀	juv.
Family **Munnidae**					
Munna sp.	123	1	—	—	—
	129	—	1	—	—
	250	1	—	—	2
Family **Pleurogoniidae**					
**Notoxenoides acalama* sp. nov.	117	—	—	1	—
Family **Haploniscidae**					
Haploniscus gernekei Kensley	117	—	1	—	—
	123	3	1	1	—
	129	3	3	3	—
	228	—	1	—	—
	236	—	1	—	—
Family **Eurycopidae**					
Eurycope glabra Kensley	129	2	3	2	—
Family **Ilyarachnidae**					
Ilyarachna wolffi Kensley	250	2	—	1	—
Family **Ischnomesidae**					
**Haplomesus zuluensis* sp. nov.	60	—	—	2	—
**Ischnomesus glabra* sp. nov.	247	—	1	—	—
**Stylomesus natalensis* sp. nov.	117	—	2	—	1
	123	—	2	—	—
	129	3	1	1	—

SYSTEMATIC DISCUSSION

INFRAORDER VALVIFERA

Family **Arcturidae**

Agularcturus gen. nov.

Diagnosis

Head and pereonite 1 fused. Eyes dorsolateral. Antennal flagellum of two articles, ending in short claw. Pereopod 1, dactylus lacking terminal claw or spine. Pereopods 2–4 lacking dactyli. Pereonite 4 elongate, broad in female, cylindrical in male. Pleon consisting of one fused pleonite plus pleotelson. Exopod of pleopod 1 in male with notch at midlength and three specialized spines. Copulatory stylet of pleopod 2 male elongate-slender, apically bifid.

Type species

Agularcturus granulatus sp. nov.

Etymology

The name is derived from the Agulhas Current, which dominates the hydrology of the east coast of South Africa, plus the suffix '*arcturus*' frequently used for members of this family.

* = new record

Remarks

Agularcturus falls into the group of genera possessing a notched exopod of pleopod 1 male, i.e. *Arcturina, Astacilla, Neastacilla, Arcturinoides, Arcturella*, and *Spinarcturus*. The absence of a claw on the dactylus of pereopod 1 distinguishes it from *Astacilla*, while the lack of dactyli on pereopods 2–4 separates it from *Neastacilla*. The single fused pleonite in the pleon separates it from the rest of the group, as does the apically bifid copulatory stylet.

Agularcturus granulatus sp. nov.

Figs 1–2

Material

East London area. Holotype SAM–A15666, SM 179, 33°30′S 27°22′E, 80 m, 1 ovig. ♀, TL 9,1 mm. Allotype SAM–A15667, SM 163, 33°04′S 28°06′E, 90 m, 1 ♂, TL 7,9 mm. Paratype SAM–A15668, SM 185, 33°39′S 27°11′E, 90 m, 1 ♂, TL 5,5 mm. Paratypes SAM–A15669, SM 163, 90 m, 1 ovig. ♀, TL 8,0 mm, 1 ♂, TL 5,5 mm, 3 juvs. Paratypes USNM 189066, SM 163, 90 m, 1 ♂, TL 8,6 mm, 1 ovig. ♀, TL 7,5 mm.

Description

Female

Dorsolateral integument densely granulate, indurate, with fairly dense pile of fine, short setules. Head with two pairs of submedian, roughly conical tubercles, posterior pair longer; anterior margin deeply concave, anterolateral corners subacute. Eyes well pigmented, triangular. Head and pereonite 1 fused, line of fusion indicated by dorsolateral groove and ventrolateral slit; well-developed ventrolateral rim concealing buccal cavity and pereopod 1 in lateral view. Pereonite 1 with large median conical tubercle; epimeron barely marked. Pereonites 2–3 subequal, each with blunt middorsal tubercle; epimera short, with straight lateral margin. Pereonite 4 broader anteriorly than long, with slight posterior taper; lateral margin a broad rounded ridge; cluster of three dorsal tubercle clumps in anterior half; distinct hollow near posterolateral corner; strong submedian pair of backwardly directed spine-like tubercles on posterior margin. Pereonites 5–6 decreasing in length posteriorly, each with middorsal spine-like tubercle, epimera roughly triangular. Pleon consisting of single fused segment bearing strong middorsal spine-like tubercle, plus broadly pentagonal pleotelson; latter lacking ornament, with strong lateral angle; apex angle obtuse.

Antennule with three-articulate peduncle and uniarticulate flagellum bearing four aesthetascs. Antenna equal in length to head plus pereonites 1–4; flagellum of two articles, ending in short claw. Mouth-parts as figured. Pereopod 1 much shorter than pereopod 2, five distal articles setose; dactylus lacking strong terminal claw. Pereopods 2–4 slender, strongly setose, dactyli lacking; three proximal articles with pile of short setules on outer margins, basal article with outer surface granulate; coxa of pereopod 4 forming major part of brood-pouch,

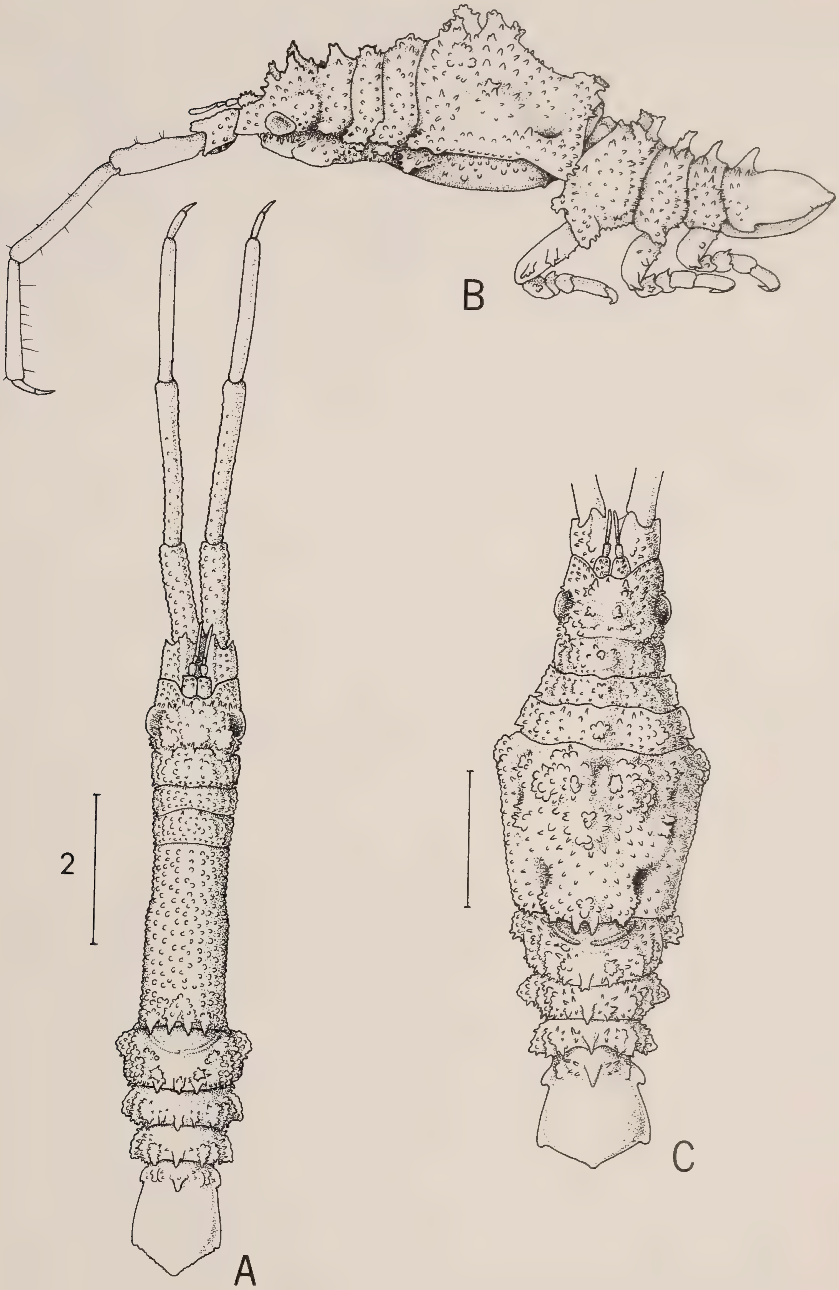

Fig. 1. *Agularcturus granulatus* sp. nov. A. Male, dorsal view. B. Female, lateral view. C. Female, dorsal view. Scales = 2 mm.

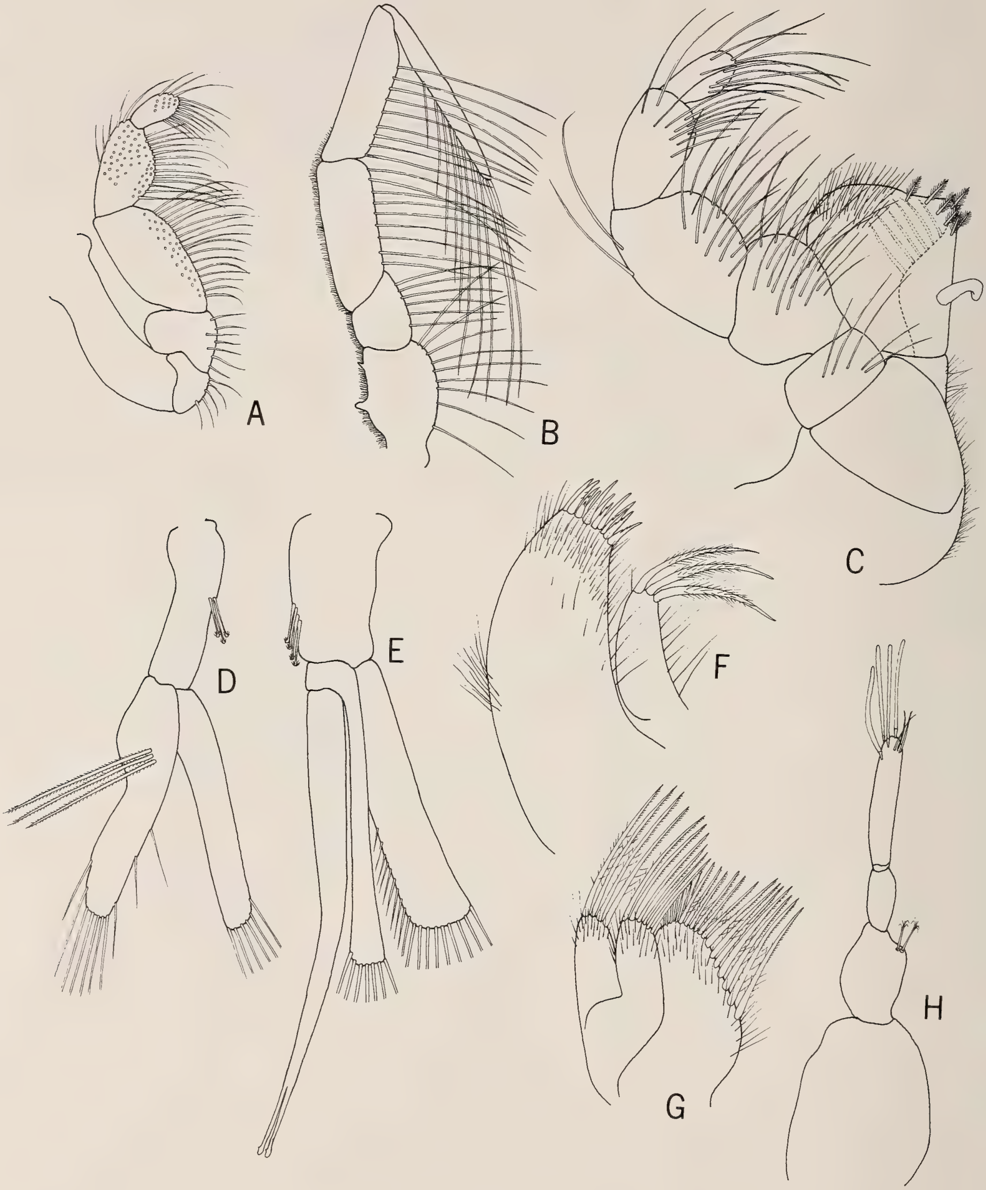

Fig. 2. *Agularcturus granulatus* sp. nov. A. Pereopod 1. B. Pereopod 2. C. Maxilliped. D. Pleopod 1 male. E. Pleopod 2 male. F. Maxilla 1. G. Maxilla 2. H. Antennule.

granulate near articulation. Pereopods 5–7 robust, all articles bearing dense pile of fine setules, longer than in anterior pereopods; bases with two spinose tubercles on outer surface.

Male

Body cylindrical, integument densely granulate. Head and pereonite 1 with low, rounded submedian tubercle. Pereonite 4 slightly longer than head plus pereonites 1–3; posterodorsal margin with four posteriorly directed spinose tubercles. Pereonites 5–7 decreasing in length posteriorly, each with strong spinose middorsal and shorter lateral tubercle. Single fused pleonite bearing single middorsal spinose tubercle. Pleotelson relatively narrower than in female. Antenna equal in length to head plus pereon. Pleopod 1, exopod with broad notch at about midlength of outer margin armed with three elongate bristled spines; about ten plumose setae on distal margin. Pleopod 2, copulatory stylet articulating near base of endopod, basally broad, tapering distally, extending by almost half its length beyond ramus, apically bifid, tips slightly broadened; endopod basally narrow, widening to distal margin bearing seven plumose setae.

Etymology

The specific name refers to the granulate integument of this species.

Antarcturus zur Strassen, 1902

Antarcturus bicornis sp. nov.

Figs 3–4

Material

Holotype SAM–A15670, SM 232, 32°14′S 29°10′E, 560–620 m, 1 ♂, TL 11,5 mm. Paratypes SAM–A15671, SM 232, 560–620 m, 2 ♂ (both damaged), 2 juvs. SAM–A15672, SM 226, 32°28′S 28°58′E, 710–775 m, 1 juv. Paratype USNM 189067, SM 232, 560–620 m, 1 ♂, TL 11,1 mm.

Description

Male

Body cylindrical, integument smooth, with few low, rounded tuberculations. Eyes lateral, well pigmented. Head with anterior pair of dorsal conical spines; anterior margin concave; ventrolateral margins not concealing pereopod 1 and mouth-parts in lateral view. Pereonite 1 fused with head, line of fusion marked by shallow dorsolateral groove, and short ventrolateral slit. Pereonites 2 and 3 similar, short. Pereonite 4 about twice length of preceding segment, cylindrical in dorsal view, with slight posterior flange. Midventral processes lacking on all pereonites. Pereonites 5–7 decreasing in length posteriorly, each with shallow transverse groove. Pleon consisting of three faintly indicated fused pleonites plus broadly convex, posteriorly rounded pleotelson.

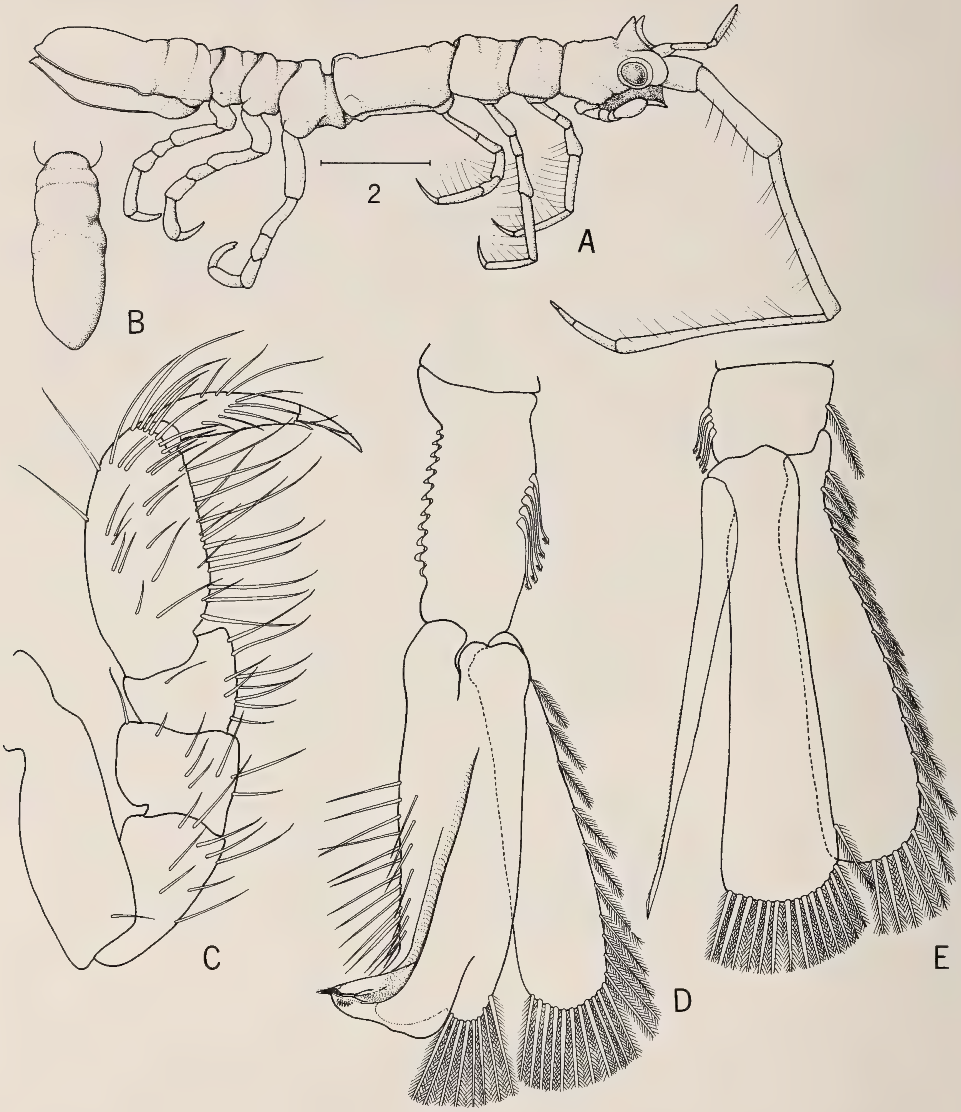

Fig. 3. *Antarcturus bicornis* sp. nov. A. Male, lateral view. B. Pleotelson, dorsal view. C. Pereopod 1. D. Pleopod 1 male. E. Pleopod 2 male. Scale = 2 mm.

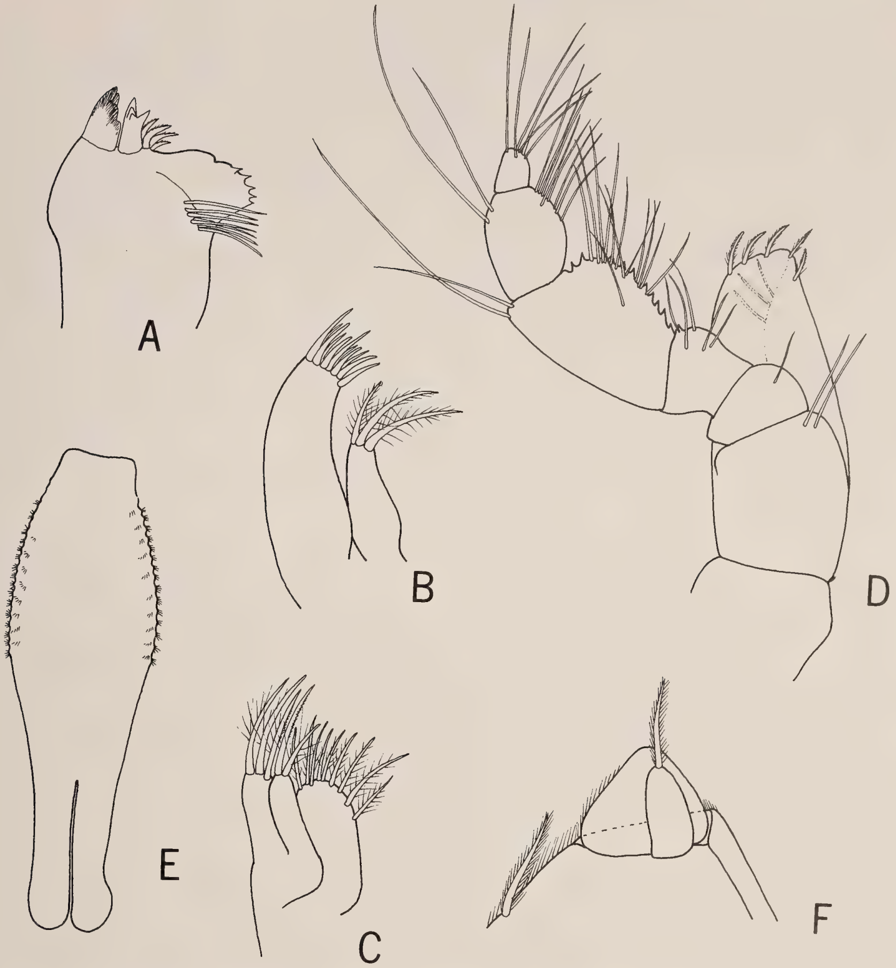

Fig. 4. *Antarcturus bicornis* sp. nov. A. Mandible. B. Maxilla 1. C. Maxilla 2. D. Maxilliped. E. Penis. F. Uropodal rami.

Antennule not reaching distal end of antennal peduncular article 3; flagellum uniarticulate. Antenna almost as long as body, articles 4 and 5 of peduncle slender-elongate; flagellum claw-like, of three articles. Mandible with tricuspid sclerotized incisor; strongly spinose lacinia; molar distally broad, armed with marginal serrations and submarginal spines. Maxilla 1, inner ramus with three stout fringed setae; outer ramus with eleven distal spines. Maxilla 2, inner ramus with nine fringed setae; inner lobe of outer ramus with two setae, outer lobe with three setae. Maxilliped, endite with eight distal fringed setae; palp of five articles, medial margin of articles 2 and 3 spinose; article 3 longest and broadest; exopod elongate-oval. Pereopod 1 armed with numerous finely fringed setae-spines on posterior margin; propodus broadest article; dactylus with strong terminal claw. Pereopods 2–4 similar, slender, becoming more elongate posteriorly; elongate setae on bases, ischia, meri, carpi, and propodi; dactyli slender, with elongate slender claw. Pereopods 5–7 similar, robust, bases becoming shorter posteriorly; fine matting of setules on inner (posterior) surfaces; dactyli curved, with short ungui. Penis distally bilobed, fused for proximal two-thirds, widest at proximal third. Pleopod 1 basis with five retinaculae on medial margin, thirteen peg-like projections on outer margin; endopod broader than exopod, with oblique groove on anterior surface, distally flexed and convoluted, with rounded mesial lobe bearing elongate plumose setae; numerous simple setae-spines on outer margin proximal to modified apex; exopod elongate-rectangular, bearing plumose setae. Pleopod 2 rami subequal, copulatory stylet articulating at base of endopod, extending just beyond ramus, tapering distally to slender grooved acute apex. Uropoda convex, rami minute, outer ramus triangular, inner ramus one-third basal width of outer, with single apical seta.

Remarks

While the elongation of pereonite 4 and the highly modified apex of the exopod of pleopod 1 is not usual, the rest of the appendages and overall structure of the present species agree with the generally accepted definition of *Antarcturus*. Until a mature female of this species is found and the generic diagnosis is settled, this would seem to be the best placement.

While several species of *Antarcturus* are relatively free of integumental spines and tubercles, none seems to resemble *A. bicornis* in having just two conical spines on the head and not having pleotelsonic ornament.

Etymology

The specific name refers to the two spines on the head of this species.

Astacilla Cordiner, 1795

Astacilla corniger (Stebbing, 1873)

Figs 5–6

Arcturus corniger Stebbing, 1873: 97, pl. 3 (fig. 2) (recorded from Algoa Bay); 1908: 51.
Arcturus (?) *corniger:* Barnard, 1914: 207.
Arcturella corniger: Barnard, 1920: 391; 1925: 381; 1940: 493, 509; 1955: 6. Kensley, 1975*a*: 37; 1978*e*: 19, fig. 7B–C.
Antarcturus ornatus Tattersall, 1913: 889, fig. 5. Vanhöffen, 1914: 526.
Astacilla setosa Vanhöffen, 1914: 525, fig. 55.
Arcturopsis hirsutus Barnard, 1914: 207, pl. 19A.
Arcturopsis hirsutus var. *subglaber* Barnard, 1914: 211.
Astacilla mediterranea non Koehler, Barnard, 1920: 388; 1940: 493, 509.
Neastacilla mediterranea: Kensley, 1978*e*: 33, fig. 15A–B.

Material

Saldanha Bay area. SAM–A52, 160 m, 1 ovig. ♀ (syntype of *Arcturopsis hirsutus* var. *subglaber*). SAM–A3888, 40 m, 3 ♂, 1 ovig. ♀, 3 ♀, 3 juvs.

SAM–A13784, 50–54 m, 2 ♂, 1 ovig. ♀. SAM–A13785, 37 m, 3 ♂, 10 ovig. ♀, 1 juv. SAM–A13787, 18–33 m, 1 ovig. ♀.

Cape Pont area. SAM–A54, 56 m, 29 ♂, 7 ovig. ♀, 7 ♀ (syntypes of *Arcturopsis hirsutus*). SAM–A55, 56 m, 24 ♂, 8 ovig. ♀, 5 ♀. SAM–A3829, 48 m, 1 ♂, 3 ovig. ♀, 1 juv. SAM–A4072, 74 m, 1 ♂.

False Bay. SAM–A53, 22 m, 1 ovig. ♀. SAM–A13786, 26 m, 3 ♂, 1 juv. SAM–A13790, 68 m, 1 ♂, 4 ovig. ♀. SAM–A13794, 73 m, 9 ♂. SAM–13795, 29 m, 1 ♂, 2 juvs. SAM–A13796, 33 m, 3 ovig. ♀. SAM–A13797, 13 m, 3 juvs. SAM–A13798, 31 m, 1 ovig. ♀. SAM–A13799, 13 m, 3 ♂, 4 ovig. ♀, 1 ♀, 2 juvs. SAM–A13800, 26 m, 5 ♂, 1 ovig. ♀, 1 ♀, 11 juvs. SAM–A13801, 26 m, 5 ♂, 2 ovig. ♀, 1 ♀, 2 juvs. SAM–A13802, 22 m, 1 ♂, 5 ovig. ♀, 1 ♀, 6 juvs. SAM–A13803, 44–48 m, 1 ♂, 1 juv. SAM–A13804, 7–9 m, 1 ♀. SAM–A13805, 26–29 m, 1 ♂, 2 ovig. ♀, 1 ♀. SAM–A13806, 15 m, 2 ovig. ♀. SAM–A13807 26–29 m, 1 ♂. SAM–A13808, 33 m, 1 juv. SAM–A13809, 29 m, 2 ovig. ♀. SAM–A13810, 31 m, 1 ovig. ♀. SAM–A13811, 29 m, 1 ovig. ♀. SAM–A13812, 68 m, 1 ♂. SAM–A13813, 31 m, 1 ♂. SAM–A13814, 42 m, 6 ♂, 2 ovig. ♀ 1 juv. SAM–A13815, 5 m, 1 ♂. SAM–A13816, 36 m, 1 ♂, 1 ♀. SAM–A13817, 27 m 5 ♂, 4 ovig. ♀, 1 ♀, 3 juvs. SAM–A13818, 1 ♂, 5 ovig. ♀. SAM–A13836, 19 m, 2 ♂.

Agulhas Bank area. SAM–A3861, 94 m, 2 ♂, 2 ovig. ♀, 1 ♀, 7 juvs. SAM–A4175, 56 m, 1 ovig. ♀. SAM–A4190, 1 ♂, 3 ovig. ♀, 1 juv. SAM–A5956, 80 m, 1 ♂, 2 ovig. ♀, 2 juvs. SAM–A6624, 40 m, 1 ovig. ♀. SAM–A13793, 110 m, 8 ♂, 2 ovig. ♀, 2 juvs. SAM–A13819, 84 m 5 ♂, 1 ovig. ♀, 1 ♀. SAM–A13820, 93 m, 1 ♂, 1 ovig. ♀, 1 juv. SAM–A13821, 45 m, 2 ovig. ♀. SAM–A13822, 49 m, 1 ♂, 1 ovig. ♀, 2 juvs. SAM–A13823, 79 m, 1 ovig. ♀. SAM–A13824, 110 m, 1 ovig. ♀. SAM–A13825, 48 m, 1 ♂. SAM–A13826, 42 m, 2 ♂. SAM–A13827, 73 m 1 ♂. SAM–A13828, 93 m, 2 ♂. SAM–A13829, 97 m, 1 ♂. SAM–A13830, 45 m, 1 ♂. SAM–A13831, 36 m, 1 ovig. ♀. SAM–A13832, 42 m, 1 ♂. SAM–A13833, 44 m, 2 ♂, 1 ovig. ♀. SAM–A13834, 42 m, 2 ovig. ♀. SAM–A13835, 110 m, 1 ♂, 3 ovig. ♀.

East London area. USNM 189068, SM 185, 90 m, 1 ♂, 1 ovig. ♀, 1 ♀, 5 juvs.

Description

Female

Head and pereonite 1 fused, line of fusion marked by shallow dorsolateral groove and short slit in ventrolateral margin. Head with large rounded-triangular eye; armed with short anterior and longer posterior pair of conical tubercles. Pereonite 1 with strong middorsal conical tubercle. Pereonites 2–3 with median conical tubercles shorter than those of pereonite 1, and with low, rounded, dorsolateral tubercles; coxal plates distinct, subcircular. Pereonite 4 longer than head and three anterior pereonites together; body widest (in dorsal view) at anterior end of pereonite 4; anterior middorsal process consisting of

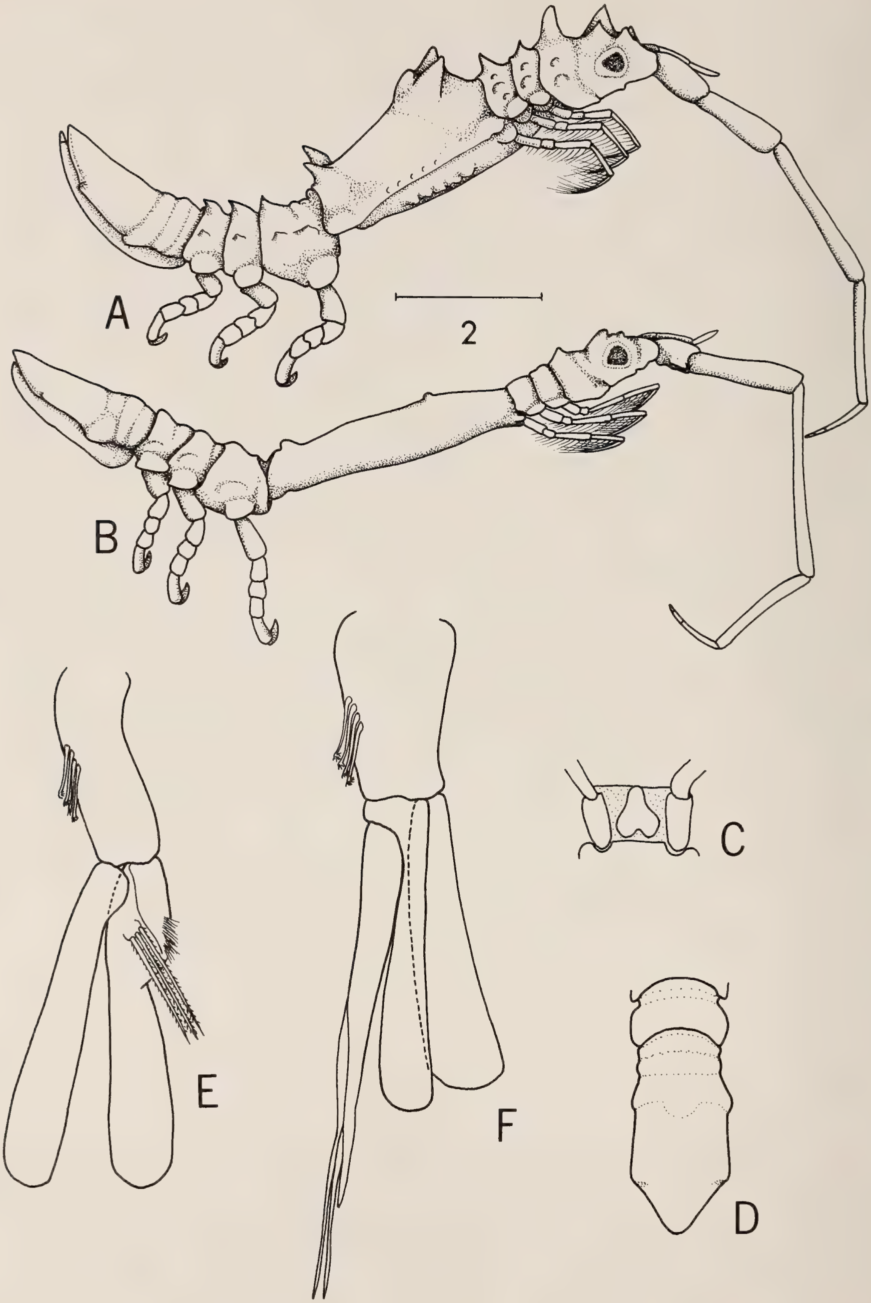

Fig. 5. *Astacilla corniger* (Stebbing) A. Female, lateral view. B. Male, lateral view. C. Pereonite 4, male, ventral view. D. Pleotelson, dorsal view. E. Pleopod 1 male. F. Pleopod 2 male. Scale = 2 mm.

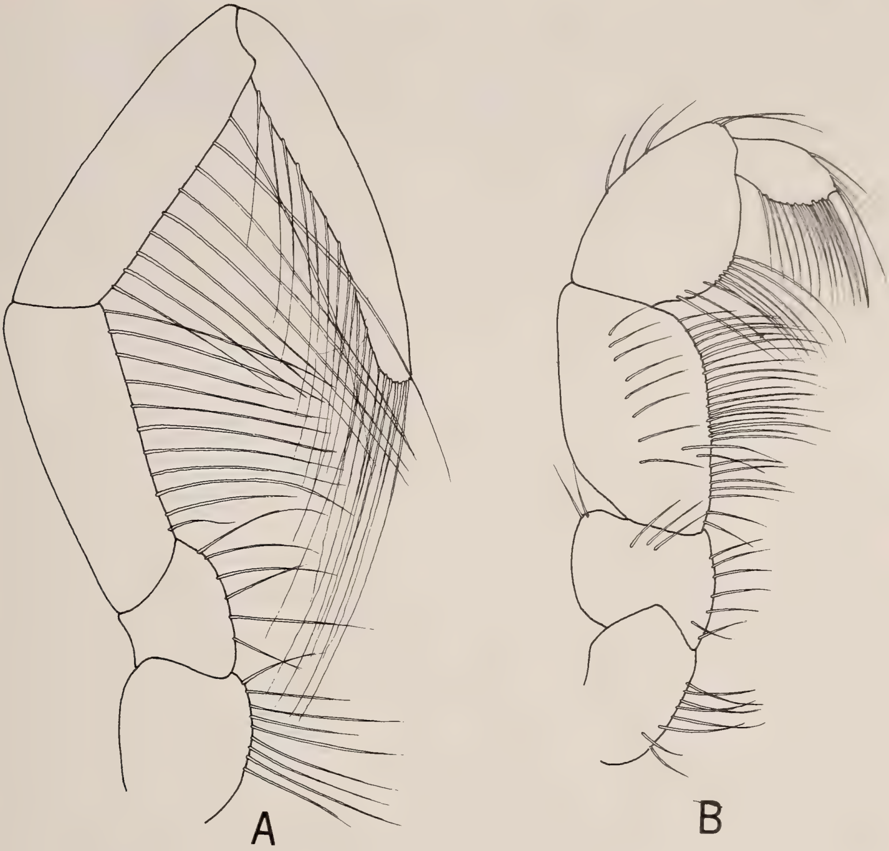

Fig. 6. *Astacilla corniger* (Stebbing) A. Pereopod 2. B. Pereopod 1.

two large lateral slightly flattened apically acute tubercles flanking shorter rounded middorsal tubercle; two large conical submedian dorsal tubercles near posterior margin; four or five low, rounded tubercles laterally; coxal plate forming major part of brood-pouch, with row of low tubercles near articulation. Pereonites 5–7 each with short conical middorsal tubercle, and low lateral tubercle; sideplates rounded. Pleon consisting of three fused segments indicated by shallow dorsolateral grooves, and pentagonal pleotelson, latter dorsally smooth, apically rounded. Antenna, if extended posteriorly, reaching pereonite 7. Mouthparts typical of genus. Pereopod 1 with ventrolateral margins concealed within ventrolateral margins of head and pereonite 1. Pereopods 2–4 increasing in length posteriorly, slender, setose. Pereopods 5–7 robust, decreasing in length posteriorly. Outer uropodal ramus very short, triangular, inner ramus much smaller, bearing single apical seta.

Male

Head with two low, rounded anterior tubercles, and two larger, rounded posterior tubercles. Pereonite 1 with single conical middorsal tubercle. Pereonite 4 elongate, subcylindrical, widening slightly at midlength, with single small middorsal rounded tubercle in anterior half, another near posterior margin. Pereonites 5–7 lacking tubercles. Antenna, if extended posteriorly, reaching to pereonite 7. Ventral process on pereonite 4 trilobed. Pleopod 1 rami subequal in length, both bearing elongate plumose setae; exopod with indentation in proximal half armed with three elongate bristled setae. Pleopod 2, rami subequal in length, bearing elongate plumose setae; copulatory stylet on endopod extending well beyond rami, terminating in one short and two more elongate slender, apically acute spinose processes.

Remarks

The chaotic state of arcturid generic taxonomy is well illustrated by the present species, *Astacilla corniger,* having been placed in six different genera since 1873. An element of doubt still remains, but the present placement in *Astacilla* was decided by several factors: pereopod 1 has a strong terminal claw on the dactylus; pereopods 2–4 lack dactyli; pleopod 1 in the male has an endopod with a median notch and three specialized setae, while the copulatory stylet of pleopod 2 is apically trifid. These four features agree with the definition of *Astacilla*, as elucidated by Lew Ton (pers. comm.). While the male of *A. corniger* has the slender body form typical of *Astacilla*, the ovigerous female is considerably broader, especially at pereonite 4, than in many other females of *Astacilla* species. Until *Arcturella* and *Arcturopsis* can be more closely defined, the present placement is perhaps the most satisfactory solution.

Sixty-five samples of *Astacilla corniger* have been examined and the degree of variation assessed. At one extreme the females have low, rounded tubercles with fairly dense pile of golden setae, the males have a low pile of setae and lack tubercles. At the other end of the range the females lack setae and have well-developed and elongate tubercles, sometimes becoming spine-like, while the males lack setae and have rounded to spinose tubercles. Between these extremes almost every variation has been noted, sometimes this variation being considerable within the same sample. There is thus no justification for maintaining Barnard's (1914) variety *subglaber*, either as a subspecies or as a separate species.

Barnard (1920) based his conclusion that his specimen from Natal was the same as the Mediterranean species on Koehler's description and somewhat diagrammatic figure. Barnard did note that the tubercle on pereonite 4 in the female was not symmetrical as in Koehler's figure. In fact, the Natal specimen was an immature specimen. With fresh material from the Mediterranean and mature material from Natal, closer comparison is possible. Pereonite 4 in the female easily separates the two species: *Astacilla mediterranea* has a single conical anterior and posterior middorsal tubercle; *A. corniger* has a trilobed anterior and a bilobed posterior middorsal tubercle. The males of the two species are more

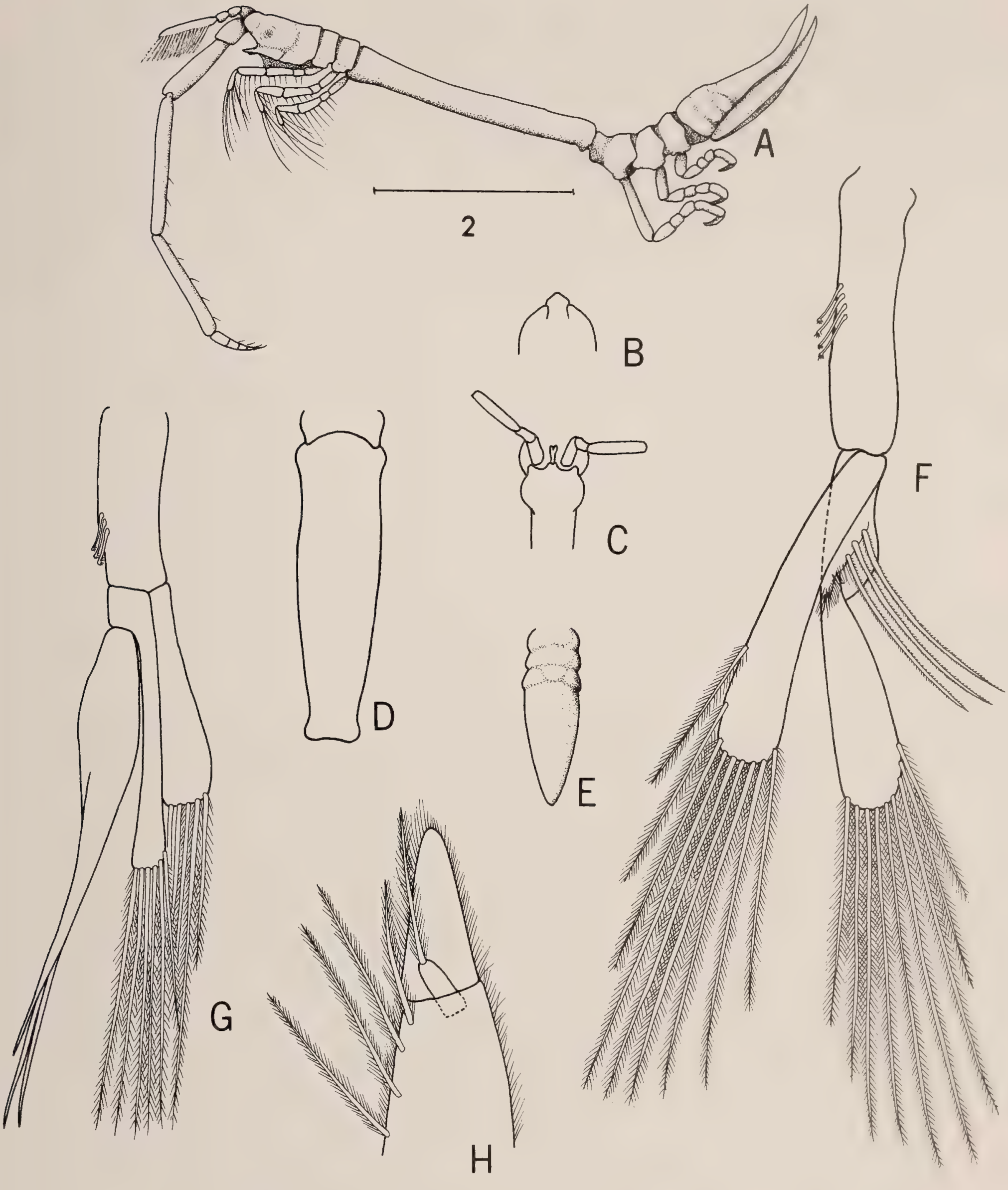

Fig. 7. *Astacilla eminentia* sp. nov. A. Male, lateral view. B. Anterior margin of head. C. Pereonite 4 male, ventral view. D. Pereonite 4 female. E. Pleotelson, dorsal view. F. Pleopod 1 male. G. Pleopod 2 male. H. Uropodal rami. Scale = 2 mm.

similar, except in pleopod structure. *A. mediterranea* has an undifferentiated pleopod 1, while the copulatory stylet of pleopod 2 is a single robust cylindrical structure. (There is a possibility that the recent Mediterranean material examined is immature, in which case this comparison is invalid). *A. corniger* possesses a modified endopod of pleopod 1, while the copulatory stylet of pleopod 2 is a slender apically trifid structure. Similar pleopodal structure is seen in *A. longispina* and *A. eminentia*.

Astacilla eminentia sp. nov.

Figs 7–8

Material

Zululand to Transkei area. Holotype SAM–A15673, SM 232, 32°14′S 29°10′E, 560–620 m, 1 ♂, TL 6,7 mm. Paratypes SAM–A15674, SM 103, 28°31′S 32°34′E, 680 m, 1 ♂, TL 6,0 mm, 3 juvs. Paratype SAM–A15675, SM 109, 28°41′S 32°36′E, 1 300 m, 1 ♂, TL 6,3 mm. Paratypes SAM–A15676, SM 232, 560–620 m, 1 ♂, TL 3,5 mm, 2 ♀, (damaged). Paratypes SAM–A17791, SM 250, 31°59′S 29°22′E, 150–200 m, 2 ♂, TL 5,1 mm, 5,3 mm. Paratypes USNM 189069, SM 226, 32°28′S 28°58′E, 710–775 m, 2 ♂, TL 7,1 mm, 7,0 mm.

Description

Male

Integument smooth, body elongate, especially pereonite 4, cylindrical. Head fused with pereonite 1, with lateral incision and dorsolateral groove indicating area of fusion; anterior margin strongly concave, with tiny rostral point; anterolateral and ventrolateral margin forming rim of buccal cavity; anteroventral margin projecting, trilobed. Eyes circular, barely pigmented. Pereonites 2–3 subequal; pereonite 4 elongate-cylindrical; pereonites 5–7 similar, becoming shorter posteriorly. Pleon consisting of three fused pleonites, each indicated by shallow grooves, plus narrowly triangular pleotelson; latter with posterior half dorsally flexed.

Antennule of three short peduncular articles and uniarticulate flagellum bearing nine aesthetascs distally. Antennal peduncle of two short proximal articles and three more elongate articles, fourth longest; flagellum of three or four articles. Mouth-parts typical of genus. Pereopod 1 within buccal rim, shorter than pereopods 2–4, four distal articles bearing elongate fringed setae; strong terminal spine present on dactylus, strong serrate spine on propodus. Pereopods 2–4 increasing in length posteriorly, dactyli absent; four distal articles bearing very elongate fringed setae. Pereopods 5–7 robust, with fine setules on posterior margins of five distal articles. Penis distally bifid, curved. Pleopod 2 with exopod shorter than endopod, both rami bearing elongate plumose setae; copulatory stylet attached near base of endopod, proximally inflated, distally tapering to trifid apex, extending to ends of endopodal setae. Uropod widest at midlength,

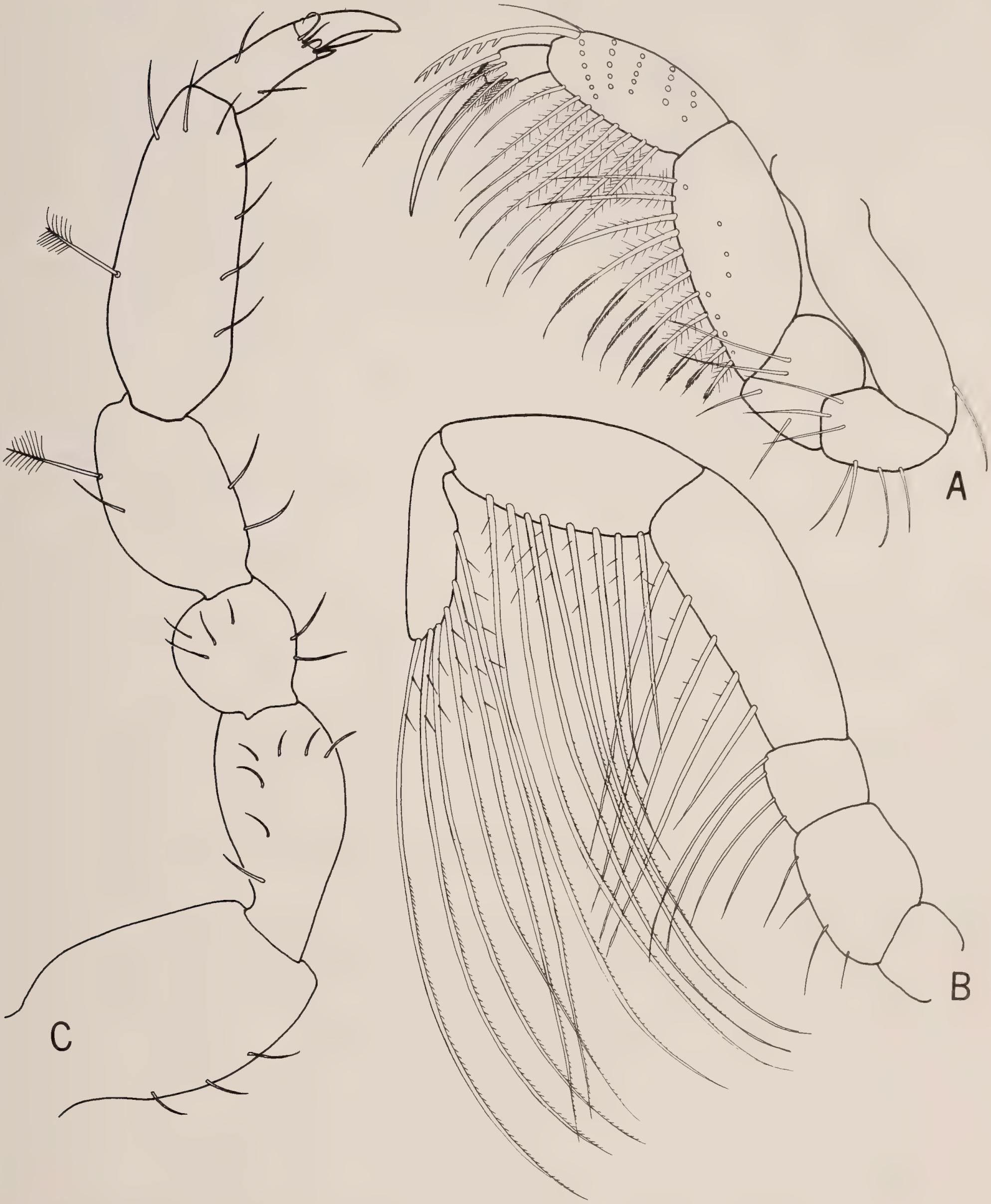

Fig. 8. *Astacilla eminentia* sp. nov. A. Pereopod 1. B. Pereopod 2. C. Pereopod 7.

narrowly tapered distally, outer ramus narrowly triangular, inner ramus tiny, bearing single terminal seta.

Female

Pereonite 4 inflated, widest at midlength; coxae and oostegites forming major part of brood-pouch.

Remarks

The present species resembles *Astacilla bacillus* (Barnard, 1920), recorded from False Bay to Zululand, in its overall slender-cylindrical form, but differs in several features, three of which easily separate these two species: pereonite 5 in *A. bacillus* is ventrally produced and markedly larger than pereonites 6 and 7; in *A. eminentia*, pereonite 5 is subequal to pereonites 6 and 7; the eye is pyriform and strongly pigmented in *A. bacillus*, circular and weakly pigmented in *A. eminentia*; the anterior buccal rim projects prominently (in lateral view) in *A. eminentia*, but is barely noticeable in *A. bacillus*. Size is a further separating feature, adult males of *A. bacillus* having a total length of 20,0 mm; adult males of *A. eminentia* reach 7,1 mm in total length.

Etymology

The specific name '*eminentia*', from the Latin meaning 'that which projects', refers to the anterior margin of the buccal rim.

Astacilla longispina (Kensley, 1978)

Neastacilla longispina Kensley, 1978*a*: 133, figs 5–6; 1978*e*: 33, fig. 14C–D.

Material

East London area. SAM–A17792, SM 250, 150–200 m, 1 ♂, 1 ♀.

Remarks

From the figure of pereopods 1 and 2 (Kensley 1978*a*, fig. 6b–c), it can be seen that this species is a typical *Astacilla sensu* Lew Ton.

Astacilla mediterranea Koehler, 1911

Fig. 9

Astacilla mediterranea Koehler, 1911: 44, figs 25–29.

Material

USNM 211346, Marseille, 75 m, 7 ♂, 2 ovig. ♀, taken from the gorgonacean *Lophogorgia sarmentosa*.

Previous records

Villefranche, Mediterranean Sea.

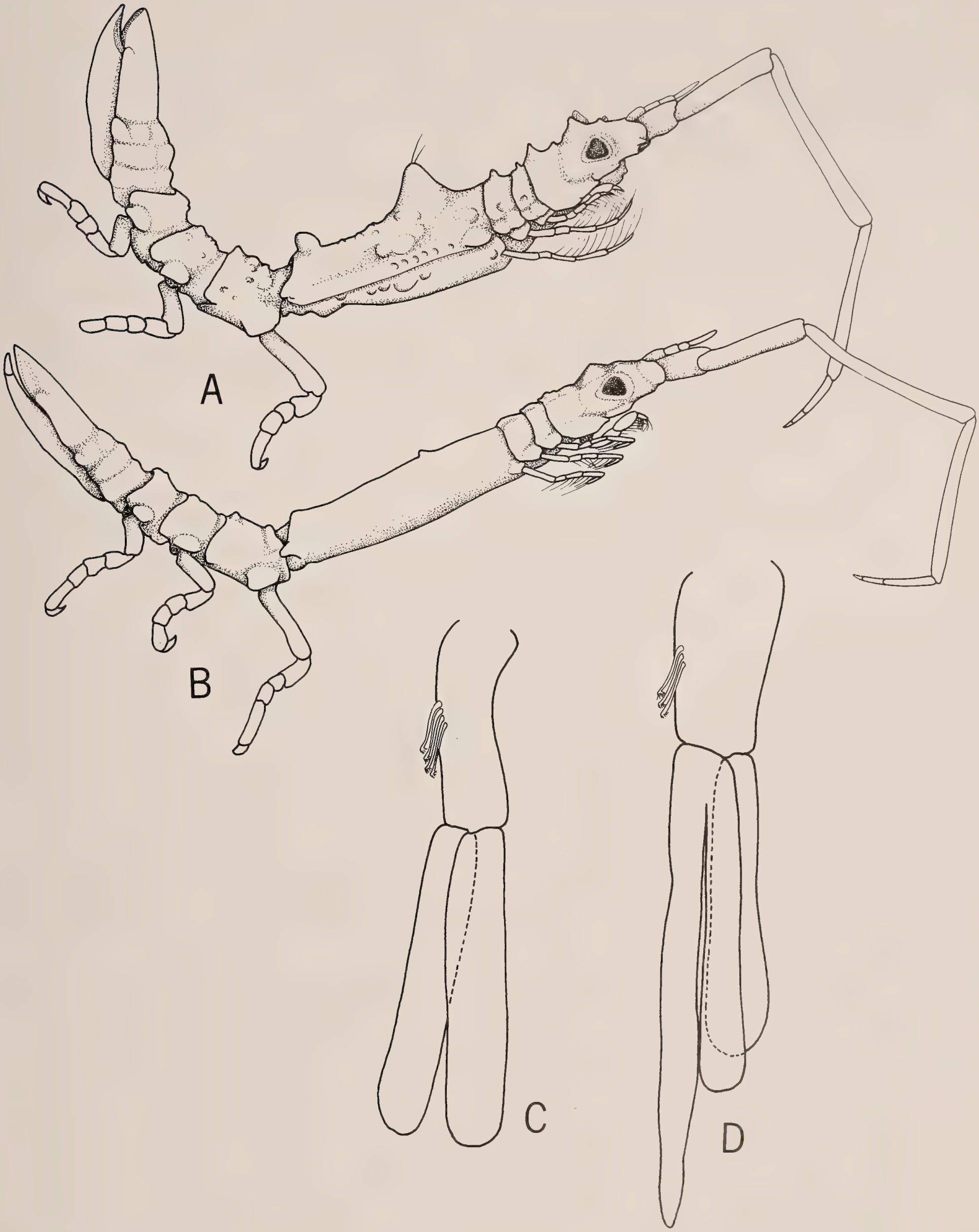

Fig. 9. *Astacilla mediterranea* Koehler A. Female, lateral view. B. Male, lateral view. C. Pleopod 1 male. D. Pleopod 2 male (immature).

Remarks

Because of the confusion with the South African *Astacilla corniger*, and because the species has not been described since 1911, the male and female are figured here.

Astacilla tranquilla (Kensley, 1975)

Fig. 10

Neastacilla tranquilla Kensley, 1975*a*: 62, fig. 13; 1978*e*: 33, fig. 15C–D.

Material

East London area. SAM–A17793, SM 164, 90 m, 1 ♂. SAM–A17794, SM 163/4, 90 m, 1 ♂, 1 juv. SAM–A17795, SM 179, 80 m, 1 ♂. SAM–A17796, SM 185, 90 m, 2 ♂.

Remarks

The first and second pereopods agree with the definition of *Astacilla sensu* Lew Ton.

Microarcturus Nordenstam, 1933

Diagnosis

Body anteriorly somewhat dorsoventrally flattened (more marked in female); seldom geniculate between pereonites 4 and 5. Head with lateral margins incised. Eyes dorsolateral and well developed and pigmented, to weakly pigmented or absent. Integument variously sculptured, frequently tuberculate. Pereonite 1 fused with head, line of fusion sometimes marked by groove. Coxae visible dorsally on all pereonites, those of pereonites 2–4 often extending laterally, triangular or semicircular in dorsal view. Pleon consisting of three fused segments plus pleotelson, two anterior fused segments demarked by shallow dorsal grooves; pleotelson often pentagonal or shield-shaped, posteriorly acute or narrowly rounded.

Antennule with three-articulate peduncle; flagellum of single article bearing aesthetascs. Antenna less than total body length; peduncle of four articles; flagellum of two articles, ending in short claw. Mandible stout, sclerotized, with well-developed incisor, lacinia mobilis, spine row, and molar. Maxilla 1 biramous, outer ramus with stout distal spines, inner with three stout setae. Maxilla 2, inner ramus with several stout distal setae; two lobes of outer ramus each with two stout elongate distal setae. Maxilliped with broad endite; five-segmented setose palp; broad epipod. Pereopod 1 considerably shorter than following legs, hidden by lateral flanges of head and pereonite 1, bearing numerous fringed spines. Pereopods 2–4 relatively slender, with elongate setae on posterior margins. Pereopods 5–7 robust, non-setose. Uropods folded ventrally, biramous, hinging with pleotelson at about midlength, basis forming most of operculum; outer ramus short, triangular, tipped with single seta; inner ramus

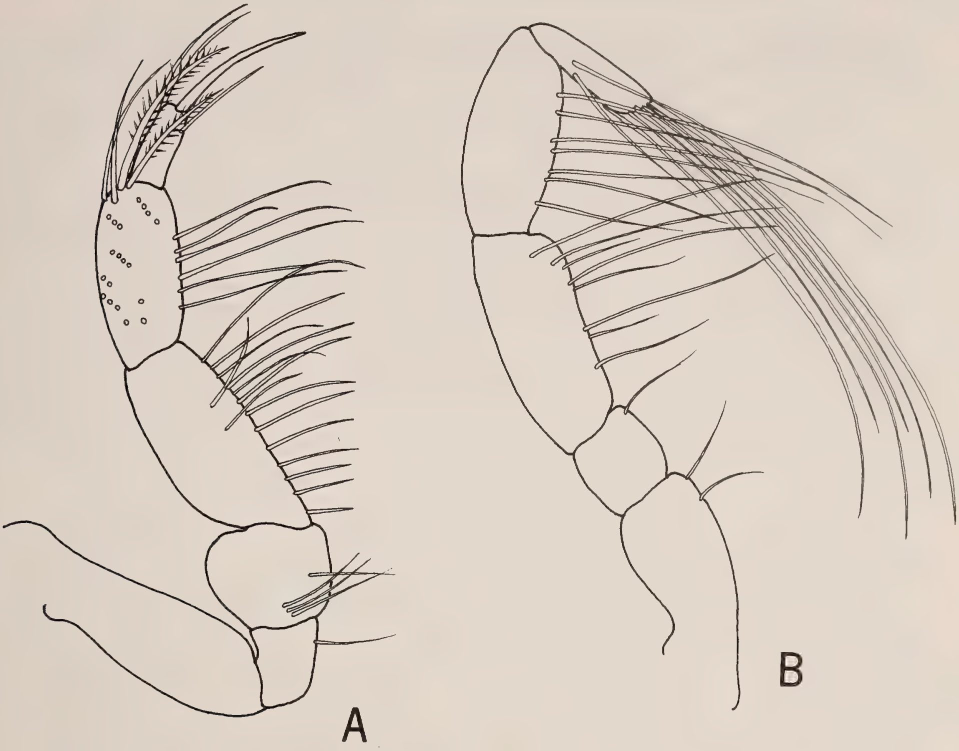

Fig. 10. *Astacilla tranquilla* Kensley A. Pereopod 1. B. Pereopod 2.

minute, with single distal seta. Penis in male elongate, curved, distally bifid. Pleopod 1 in male, basis with three to five retinaculae on medial margin, row of five to fifteen peg-like spines on outer margin, posterior face grooved, distally rounded and variously convoluted, distal margin with several elongate plumose setae; endopod varying in length from being equal in length to exopod, to less than half length and width of exopod. Pleopod 2 in male with stout grooved copulatory stylet articulating at base of endopod; apex of copulatory stylet varying from simple gutter-like opening, to bilobed and convoluted.

Remarks

Nordenstam (1933) separated twelve species under *Microarcturus*, from an unwieldy group of species variously described as *Antarcturus* or *Arcturus*, on the following criteria: antennae shorter than total body length, with flagellum of three articles (rarely two or four); abdomen short, never longer than last four pereonites. Nordenstam (1933: 128) also noted that *Microarcturus* contained 'small forms'.

Hale (1946) noted that at least one species mentioned by Nordenstam under *Microarcturus* possesses a longitudinally cleft exopod of pleopod 1 in the male, thereby placing it closer to *Pseudarcturella*, while in another species the pleon is slightly longer than the last four pereonites. Thus the character of the length of the antennae alone separates *Microarcturus* from closely related forms.

Yet another difference between *Microarcturus* and *Antarcturus* not hitherto noted lies in the structure of the lateral flanges of the head and pereonite 1. This is similar to the criterion used by Zur Strassen (1902) to separate *Arcturus* and *Antarcturus*. In *Antarcturus*, there is almost no development of a lateral flange on the head below the eyes, and on pereonite 1. The mouth-parts and pereopod 1 are thus exposed in lateral view. In *Microarcturus* there is some development of lateral flanges, but not sufficient to conceal completely the mouth-parts and pereopod 1 in lateral view, as in *Arcturus*. Another, but not very satisfactory, feature of difference is that of the general body shape of gravid females. In *Antarcturus* ovigerous females retain an overall, generally cylindrical, shape, with barely a bulge in the region of the marsupium. In *Microarcturus* ovigerous females are distinctly broadened in the region of the marsupium with a degree of dorsoventral flattening.

In the present discussion of *Microarcturus* species have been recognized primarily on the basis of body shape–ornamentation combination, plus the structure of the male reproductive appendages. Taken alone, body shape–ornamentation would be an insecure basis for species separation, especially considering the degree of variation already noted in the group (e.g. *M. similis, M. stebbingii*, in Nordenstam 1933: 159). In this study sixty-five samples of *M. similis* have been examined, giving a good idea of the range of variation in body shape and integumental sculpturing. The shape of the epimera of pereonites 2–4, being either triangular and acute, or semicircular, remains constant, regardless of the integumental ornamentation. It is unfortunate that Schultz (1982*b*), in designating new astacillid genera, did not supply information or figures for several, basing them instead on integumental ornamentation and presence or absence of eyes. The former feature, as noted above for *M. similis*, and for *M. halei* (p. 243) (and for *Arcturides cornutus*, in Kensley 1980) can be variable both within and between species. Eyes may be present or absent, as demonstrated in species of *Microarcturus*.

The first and second pleopods of the male provide another set of features considered useful for specific separation. On the outer margin of the bases of pleopod 1 some variation in the number of peg-spines has been noted, but generally not varying by more than one or two spines within a species. The exopod of pleopod 1 in the male is grooved on the posterior face and the distal part generally bears a rounded lobe bearing elongate plumose setae plus a variously shaped finely setulose lobe in the area of the distal end of the groove. There would appear to be a trend in reduction in size and setation of the endopod, being of equal length to the exopod in *M. similis*, and less than half the length and width, and with few plumose setae, in *M. oudops*. This trend may be correlated with depth, the reduction being clearest in the deepest occurring species. The copulatory stylet of pleopod 2 in the male varies from being a simple tapering gutter-like structure to an almost closed tube having a bilobed and convoluted apex. Within a species there would seem to be little variation in the adult in these appendages.

Distribution

As most of the twelve species of *Microarcturus* discussed here have been taken from a very few collecting stations, the following remarks must be treated with caution.

Six species have not been recorded from depths beyond 100 m and may be termed shallow-continental shelf forms; three species have been recorded from 150 m to depths in excess of 700 m—these may be termed deep shelf-slope species; three species have been taken beyond 550 m only and may be termed slope species. Of these latter, *M. oudops* (680–1 500 m) has weakly pigmented eyes, while *M. biserialis* (1 300 m) lacks eyes completely. (See Table 1.)

The evolutionary radiation of the twelve South African species of *Microarcturus* gives rise to some observations, in spite of the relatively few stations involved. From Saldanha Bay to the Agulhas Bank four species have been taken from shallow water (9–88 m). (*M. similis* has also been taken from a single station off Lüderitz.) As this area has been well sampled to depths of 200 m, it can be said with some confidence that the known range of these species reflects their true geographical distribution. These four species seem to form a natural group, having a simple, open copulatory stylet and relatively simple endopodal apices to pleopod 1 in the male. The six east-coast species from shallow to shelf-slope depths also seem to form a natural group, having convoluted apices of the stylet and pleopod 1 in the

TABLE 1

Distribution of southern African *Microarcturus*.

Species	Depth range	Geographic range	Depth category
dayi	9–18	False Bay	shallow shelf
similis	15–88	Saldanha Bay–Still Bay	shallow shelf
quadriconus	22–80	False Bay–Still Bay	shallow shelf
laevis	48–81	False Bay–Agulhas Bank	shallow shelf
nordenstami	90	East London	shallow shelf
ornatus	150–700	Still Bay–Transkei	deep shelf/slope
longispina	150–775	Transkei	deep shelf/slope
halei	150–1 300	Transkei–Zululand	deep shelf/slope
youngi	550–680	Zululand	slope
oudops	680–1 500	Cape Point–Zululand	slope
biserialis	1 300	Zululand	slope

male. The deeper occurring species (*M. ornatus* and *M. halei*) appear to have relatively wide geographic ranges, while the two shallow species (*M. barnardi* and *M. nordenstami*) appear to have a more restricted range.

On a somewhat restricted scale, this distribution pattern agrees with that of other isopod groups, e.g. the anthuridans, viz. shallow species with high endemicity and narrow ranges, deep species with wide geographic ranges.

As little is known of the distribution of the non-South African species of *Microarcturus*, some of which are taxonomically poorly defined, no further speculation on the history of the genus can be made.

In the following discussion of individual species a diagnosis is given for each, covering only the features used for separation. Figures of whole animals plus relevant appendages are also provided. Only for *M. similis*, the most frequently recorded species, are all the appendages figured.

Microarcturus barnardi sp. nov.

Fig. 11

Material

East London area. Holotype SAM–A17797, SM 163, 33°04′S 28°06′E, 90 m, 1 ovig. ♀, TL 5,0 mm; allotype, 1 ♂, TL 5,0 mm. Paratypes SAM–A17798, SM 163, 90 m, 5 ♂, 1 ovig. ♀, 12 juvs. USNM 189070, SM 163, 90 m, 4 ♂, 2 ovig. ♀.

Diagnosis

Integument with numerous rounded tubercles. Tuberculate supraocular ridges fairly prominent, but not as strong as in *M. nordenstami*. Eyes dorsolateral, well pigmented. Pereonites 2–4 each with central clump of tubercles anterodorsally. Epimera of pereonites 2–3 broadly oval in female, epimeron 4 reduced. Pleotelson apically narrowly rounded, lacking lateral angle, with large elongate tubercles dorsally. Bases of pereopods 2–4 unarmed. First fused pleonite in male with single dorsal row of tubercles; second fused pleonite consisting of two large rounded tuberculate bosses, markedly inflated and convex in lateral view. Third fused pleonite with single middorsal rounded tuberculate boss. Pleopod 1 in male, distal margin rounded, bearing eight short plumose setae, running imperceptibly into finely setulose rounded lobe in area at end of groove; endopod about three-fourths length of and slightly more than half width of exopod. Copulatory stylet of pleopod 2 distally bilobed and convoluted.

Remarks

This species was collected with a single specimen of *M. nordenstami* off East London, in 90 m. These two species may easily be separated by the strong carunculated supraocular ridges, granulate pereonal bosses, and angled pleotelson of *M. nordenstami*, and the swollen fused pleonite 2 and non-angled pleotelson of *M. barnardi*.

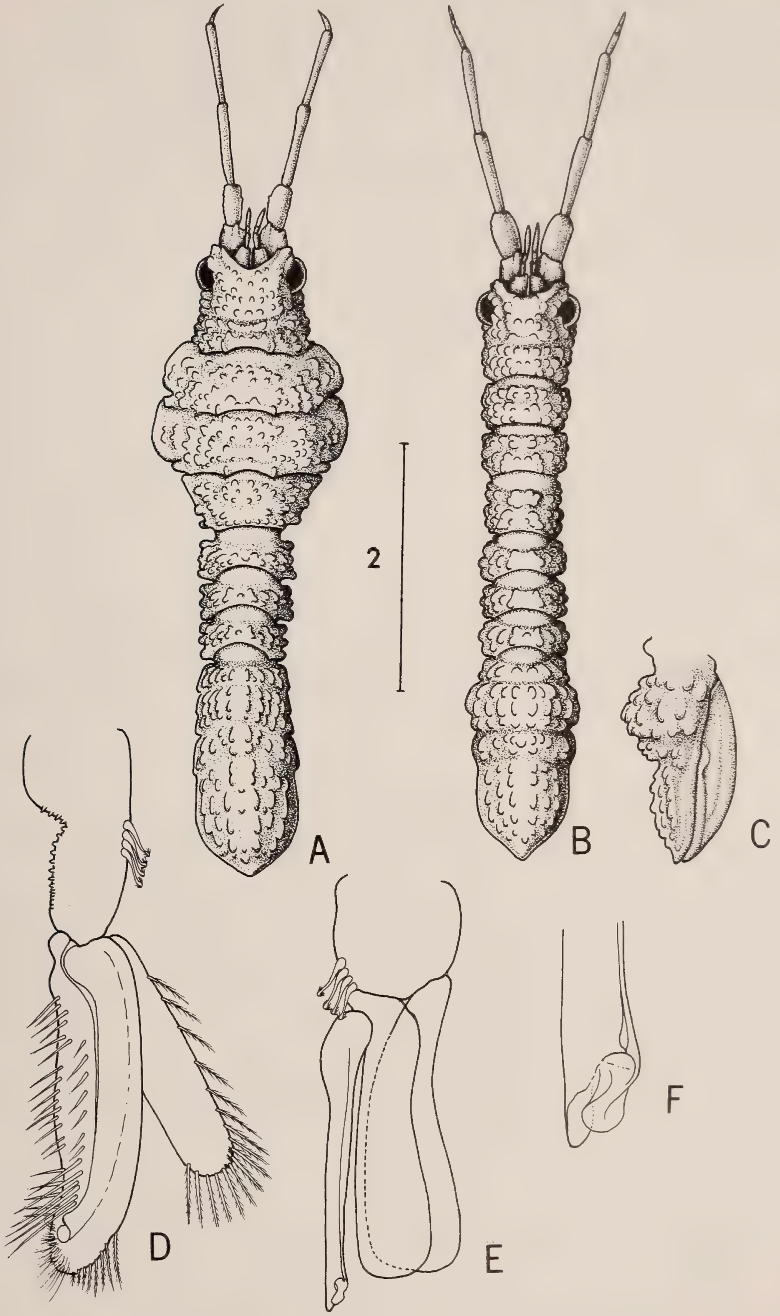

Fig. 11. *Microarcturus barnardi* sp. nov. A. Female, dorsal view. B. Male, dorsal view. C. Pleotelson, male, lateral view. D. Pleopod 1 male. E. Pleopod 2 male. F. Apex of copulatory stylet. Scale = 2 mm.

Etymology

The species is named for the late Dr K. H. Barnard who contributed much knowledge to isopod systematics.

Microarcturus biserialis Kensley, 1978

Fig. 12

Microarcturus biserialis Kensley, 1978*a*: 128, fig. 2; 1978*e*: 27, fig. 11A–B.

Material

Holotype SAM–A15467, 1 300 m, 1 ♂; paratypes, 2 ♂.

Diagnosis

Integument finely granulate. Head lacking eyes or even unpigmented ommatidia; with one pair of narrow submedian processes. Pereonites 1–7 each with one pair submedian conical processes. Epimera of pereonites 2–3 short, triangular. Fused pleonites 1–3 each with submedian pair of conical processes, anterior pair smallest. Pleotelson with distinct lateral angle, posterior margin broadly triangular. Pleopod 1 ♂, with distal margin of exopod formed by finely setulose lobe, evenly convex; three short plumose setae medially; endopod slightly less than half length of exopod, lacking elongate plumose setae, having only fine setules. Copulatory stylet robust, open, distally acute, simple. Female unknown.

Microarcturus dayi Kensley, 1977

Fig. 13

Microarcturus dayi Kensley, 1977: 246, figs 6–7; 1978*a*: 133; 1978*e*: 28, fig. 11C–E.

Material

Saldanha Bay area. SAM–A5952, 240 m, 1 ♂.

False Bay area. SAM–A13843, 75 m, 1 ♂, 1 ovig. ♀. SAM–A13895, 87 m, 2 ovig. ♀. SAM–A17799, 75 m, 1 ♂, 2 ovig. ♀.

Agulhas Bank. SAM–A13772, 78 m, 1 ♂, 2 ovig. ♀, 2 juvs. SAM–A13773, 106 m, 2 ♂. SAM–A17800, 84 m, 1 ♂, 2 ♀, 3 juvs.

East London area. SAM–A17801, SM 179, 80 m, 1 ♂. SAM–A17802, SM 180, 80 m, 6 ♂, 1 ovig. ♀, 4 juvs.

Diagnosis

Integument with numerous small tubercles; 1 pair large conical tubercles on head; female with pair of large flattened submedian tubercles on pereonite 3; male and female with conical, posteriorly directed middorsal spine on fused pleonite 3. Epimera of pereonite 2 triangular, distally rounded, of pereonite 4 rectangular in female, with marginal denticulations, reduced in male. Pleotelson pentagonal, with strong subspinose lateral angle.

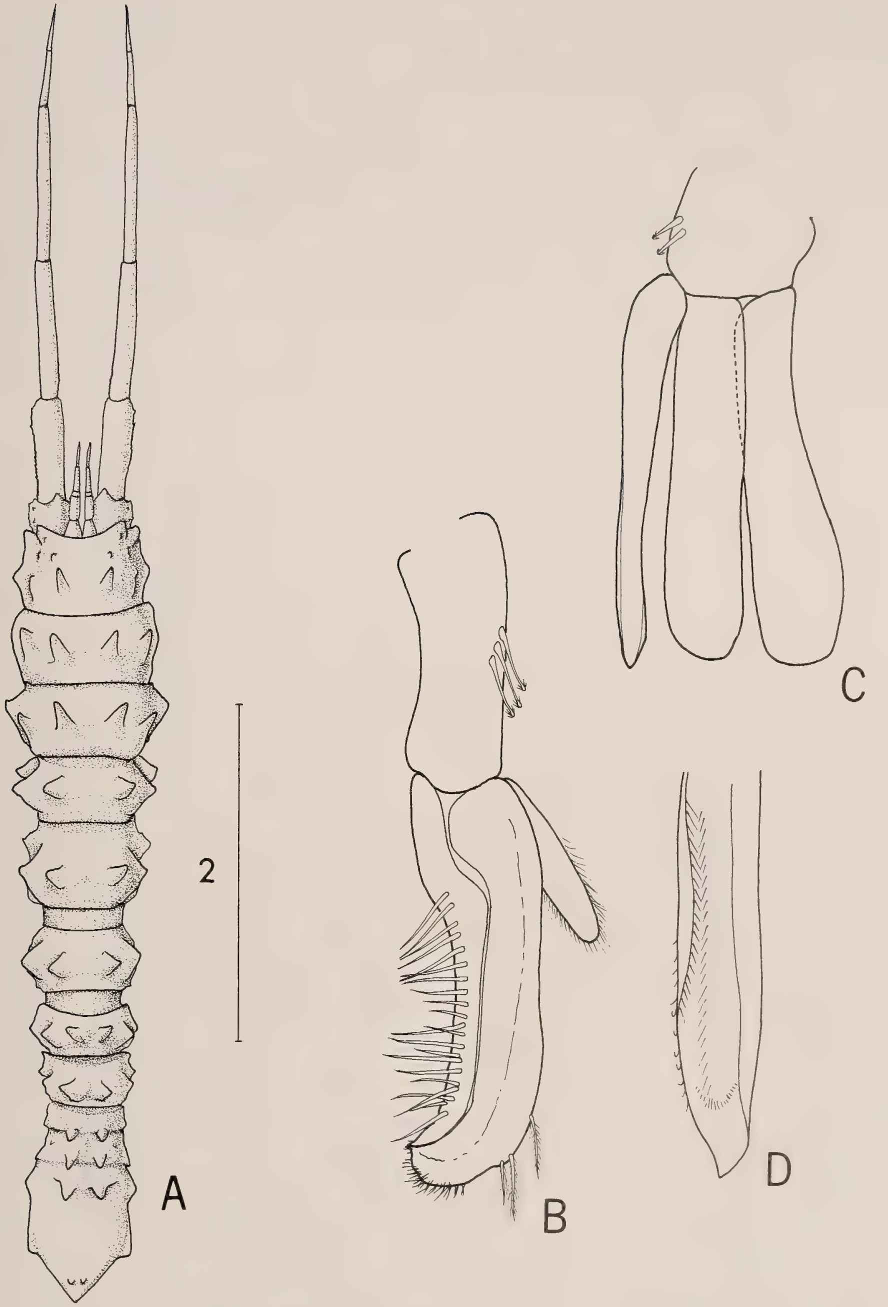

Fig. 12. *Microarcturus biserialis* Kensley A. Male, dorsal view. B. Pleopod 1 male. C. Pleopod 2 male. D. Apex of copulatory stylet. Scale = 2 mm.

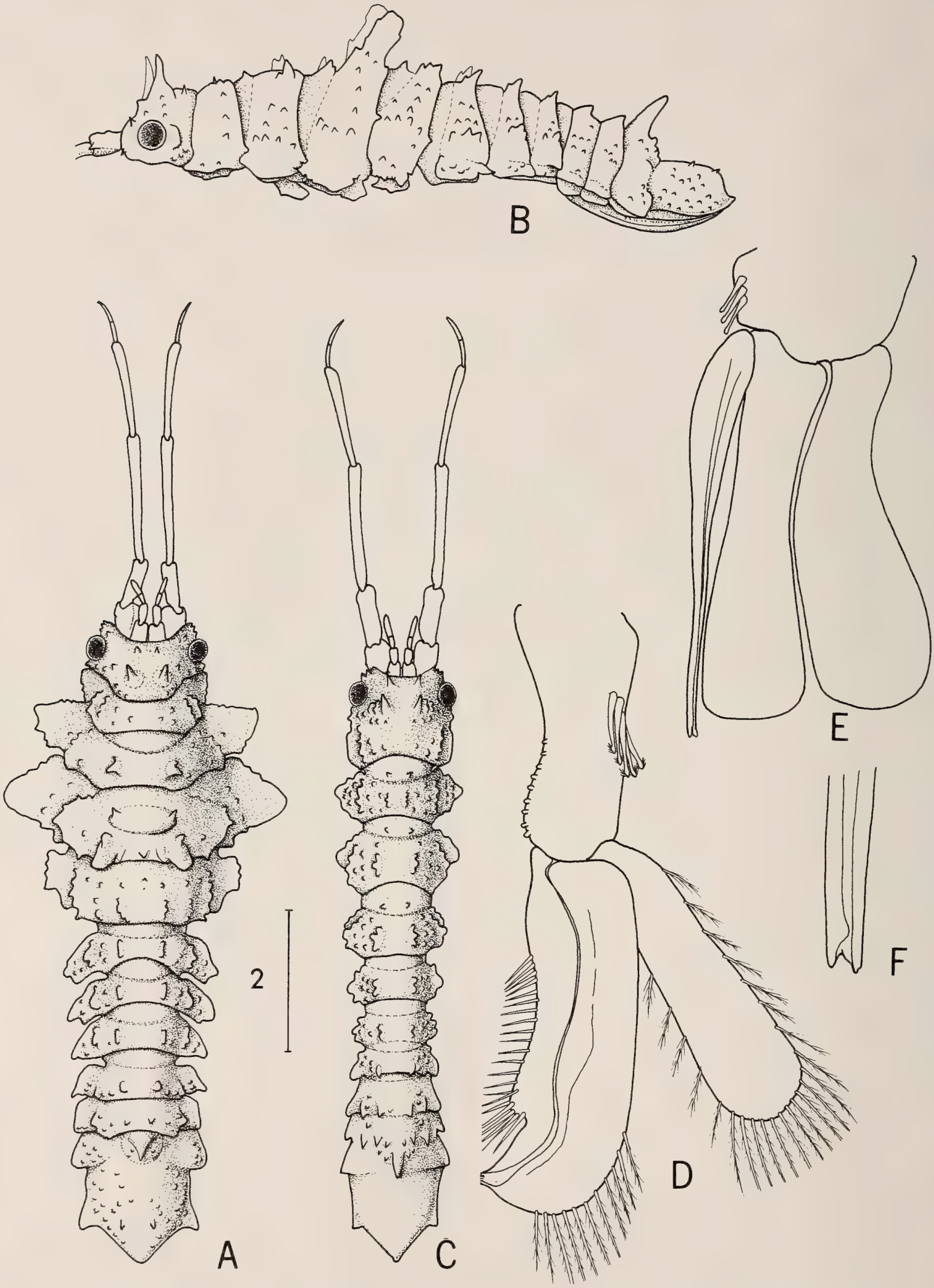

Fig. 13. *Microarcturus dayi* Kensley A. Female, dorsal view. B. Female, lateral view. C. Male, dorsal view. D. Pleopod 1 male. E. Pleopod 2 male. F. Apex of copulatory stylet. Scale = 2 mm.

Pleopod 1 ♂, exopod with distal margin bearing 11 plumose setae, very similar to *M. similis*; endopod subequal in length and width to exopod. Copulatory stylet an open gutter, with slight subterminal lobe.

Remarks

Microarcturus dayi and *M. quadriconus* have been taken from the same sample from False Bay.

The ornamentation of *M. dayi* bears some resemblance to *M. ornatus*, but the latter has more flattened dorsal tubercles, epimera 3–5 are semicircular in dorsal view, and both male and female lack a middorsal pleonal spine.

Microarcturus halei sp. nov.

Fig. 14

Material

Zululand to Transkei area. Holotype SAM–A17803, SM 103, 28°31′S 32°34′E, 680 m, 1 ovig. ♀, TL 5,8 mm. Paratypes SAM–A17804, SM 103, 680 m, 8 ♂, 3 ovig. ♀. Paratypes SAM–A17805, SM 250, 31°59′S 29°22′E, 150–200 m, 4 ♂, 4 ovig. ♀, 17 juvs. SAM–A17806, SM 123, 690 m, 2 ♂, 2 ovig. ♀. SAM–A17807, SM 109, 1 300 m, 1 ovig. ♀. SAM–A17808, SM 232, 560–620 m, 14 ♂, 4 ovig. ♀, 4 juvs. SAM–A17809, SM 226, 710–775 m, 11 ♂, 6 ovig. ♀, 20 juvs. USNM 189071, SM 250, 2 ♂, 2 ovig. ♀. USNM 189072, SM 103, 3 ♂, 1 ovig. ♀.

Diagnosis

Integumental ornamentation variable, either relatively smooth between large tubercles or with numerous fine acute granulations. Head with anterolateral corners acute; eyes large, weakly pigmented. Pereonite 2 with two or four elongate conical processes; occasionally, pereonites 2–3 each with four conical processes; epimera of pereonites 2–3 triangular, distally narrowly rounded to almost acute. Pereonites 5–7 subequal in length, decreasing in width posteriorly. Bases of pereopods 2–4 with two or three spinose processes on anterior margins; coxal processes acutely triangular. Three fused pleonites demarked by shallow grooves; pleotelson pentagonal, with strong lateral angle or tooth; apically acute.

Pleopod 1 ♂, exopod with distal rounded margin bearing nine elongate plumose setae; groove opening on small curled lobe; with convex finely setulose distal lobe; endopod five-sixths length and about half width of exopod. Copulatory stylet stout, distally bilobed.

Remarks

The finely granulate form of *Microarcturus halei* has an integument similar to that of *M. hirticornis* (Monod) from the Antarctic, but differs markedly from this species in having fewer elongate dorsal processes, and in having a

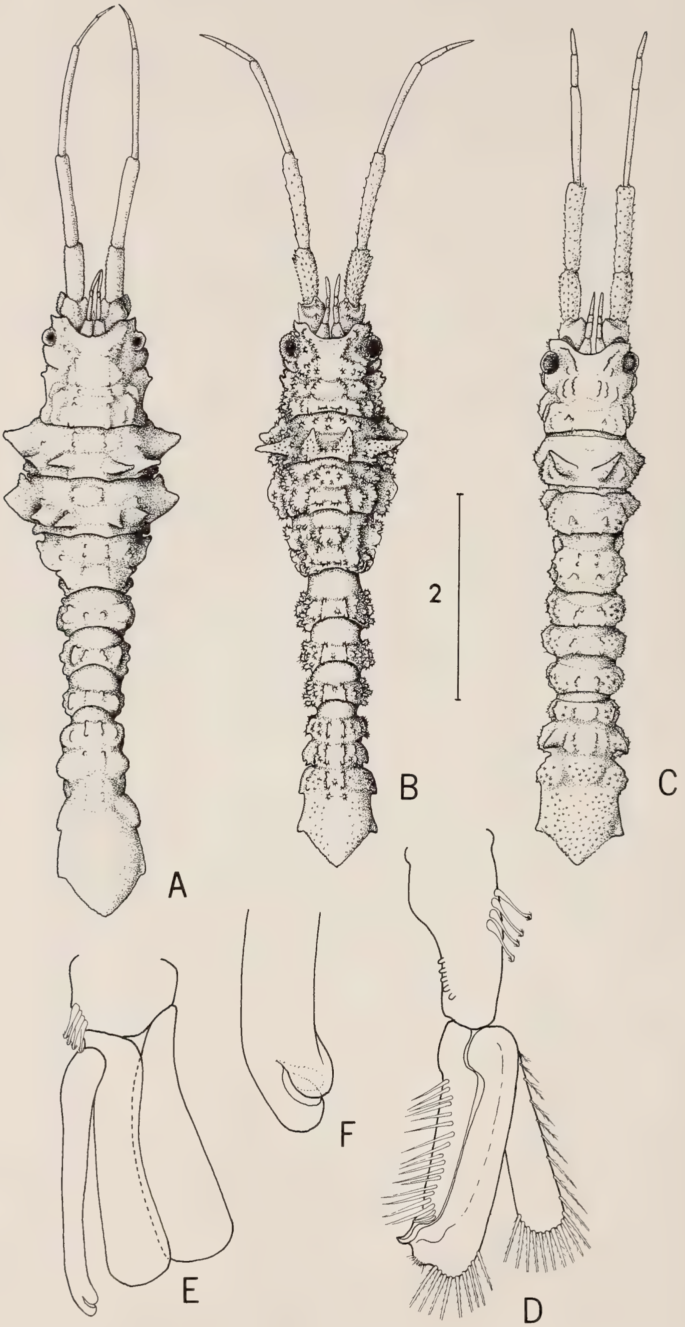

Fig. 14. *Microarcturus halei* sp. nov. A. Female, dorsal view. B. Female, dorsal view. C. Male, dorsal view. D. Pleopod 1 male. E. Pleopod 2 male. F. Apex of copulatory stylet. Scale = 2 mm.

posteriorly acute, rather than a bifid pleotelson. The arrangement of conical tubercles on the dorsum differs from any of the other South African species of *Microarcturus*.

Etymology

The species is named for the late H. M. Hale who contributed much valuable work to arcturid systematics.

Microarcturus laevis Kensley, 1975

Fig. 15

Microarcturus laevis Kensley, 1975*a*: 48, fig. 6; 1978*e*: 28, fig. 12A–B.

Material

False Bay. Holotype SAM–A13544, 75 m, 1 ovig. ♀. Paratype SAM–A13545, 48 m, 1 ovig. ♀. SAM–A13837, 66 m, 2 ♂, 1 ♀. SAM–A13852, 66 m, 11 ♂, 8 ovig. ♀, 4 ♀, 4 juvs. SAM–A13879, 81 m, 1 ♂.

Agulhas Bank. SAM–A13883, 78 m, 1 ♂.

Diagnosis

Integument smooth, occasionally very faintly pitted, lacking other ornamentation. Head with convex bulge between eyes, sometimes tending to be double, especially in males. Epimera of pereonites 2–4 rounded. Pereonites 2 and 3 with evenly convex submedian dorsal bulges. Pleotelson shield-shaped, apically acute, lacking distinct lateral angle; base of pleotelson with low rounded mid-dorsal convexity. Pleopod 1 ♂ with exopod distally rounded, with ten dorsal plumose setae; margin between end of groove and spine cluster on outer margin gently convex; endopod subequal in length and width to exopod. Copulatory stylet of pleopod 2 exopod distally simple, open, gutter-like.

Remarks

The rounded epimera of pereonites 2–4 and the lack of conical tubercles distinguishes this species from *M. quadriconus*, which it otherwise closely resembles.

Microarcturus longispinus sp. nov.

Fig. 16

Material

East London area. Holotype SAM–A17810, SM 226, 32°28′S 28°58′E, 710–775 m, 1 ovig. ♀, TL 6,2 mm. Allotype SAM–A17811, SM 228, 32°29′S 28°57′E, 650–700 m, 1 ♂, TL 6,5 mm. Paratypes USNM 189073, SM 250, 31°59′S 29°22′E, 150–200 m, 2 ♂, 1 ovig. ♀, 1 juv.

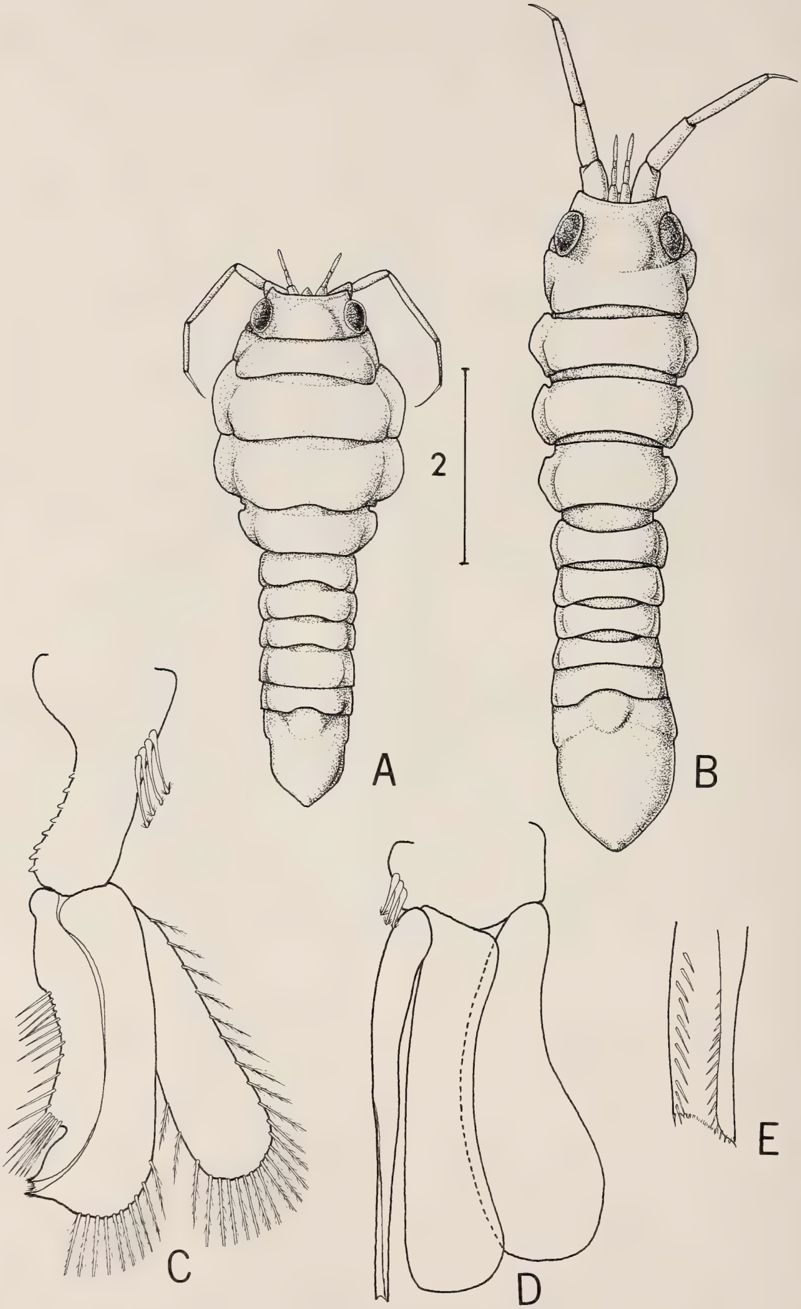

Fig. 15. *Microarcturus laevis* Kensley A. Female, dorsal view. B. Male, dorsal view. C. Pleopod 1 male. D. Pleopod 2 male. E. Apex of copulatory stylet. Scale = 2 mm.

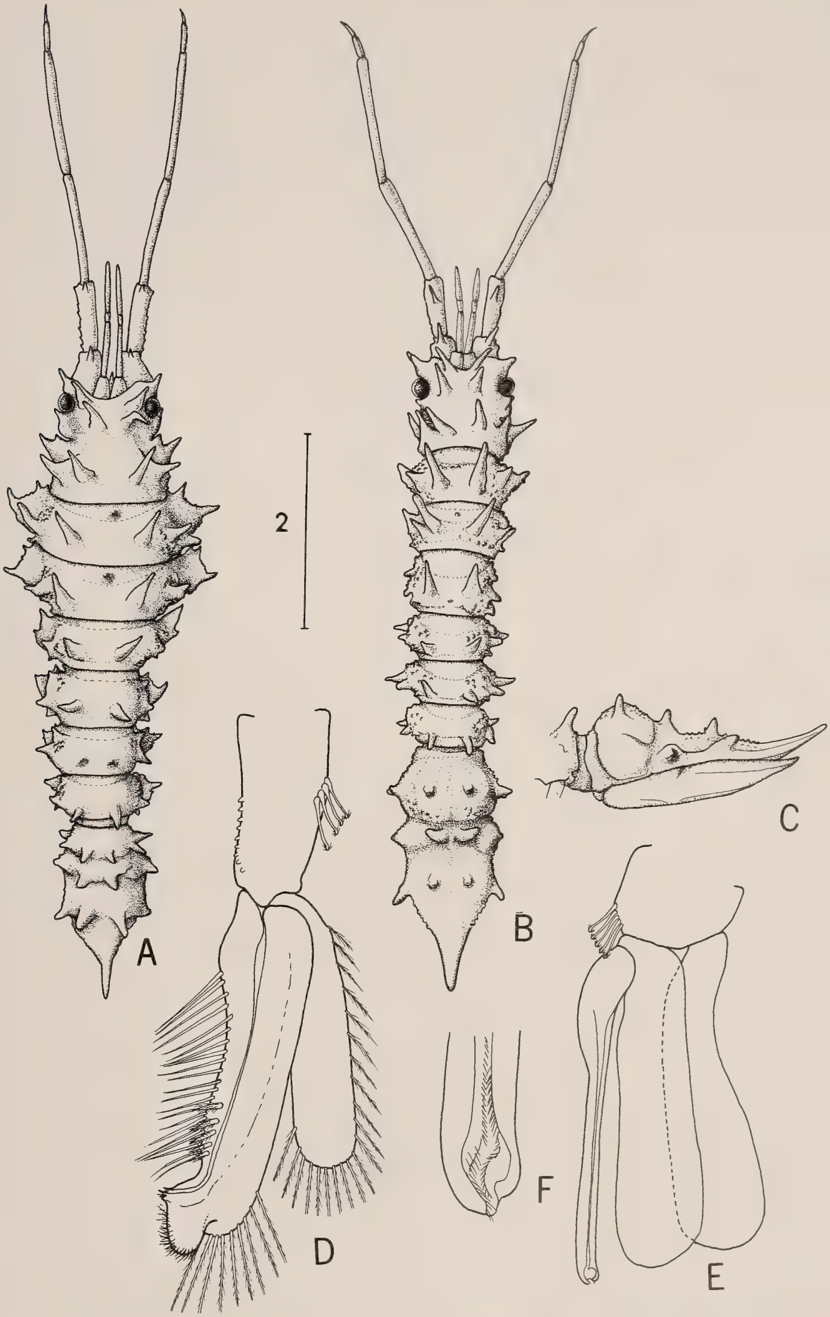

Fig. 16. *Microarcturus longispinus* sp. nov. A. Female, dorsal view. B. Male, dorsal view. C. Pleotelson, lateral view. D. Pleopod 1 male. E. Pleopod 2 male. F. Apex of copulatory stylet. Scale = 2 mm.

Diagnosis

Integument finely granulate. Eyes well pigmented. Male, head with two pairs of submedian conical processes; all pereonites with two pairs of elongate conical processes; second fused pleonite inflated, with six elongate processes; third fused pleonite with four elongate processes; pleotelson tapering posteriorly, dorsally flexed, acute, with one pair of submedian processes, lateral angle produced into elongate process. Female with pereonites 2–3 each with single anterior middorsal elongate process, epimera triangular, acute, with one or two small spines on anterior margin; epimeron of pereonite 4 truncate, with anterior spine. Male with bases of pereopods 5–6 with laterally directed spinose process; merus of pereopods 2–4 with distolateral spinose process. Female with pereopods 2–4 armed with spines on merus, ischium, basis, and coxa; coxal processes of pereopods 2–4 subcircular, increasing in size posteriorly; pereopods 5–6 with single spinose process on outer margin of basis. Pleopod 1 ♂, exopod with finely setulose lobe distal to end of groove elongate, rounded, extending beyond rounded distal margin; latter with nine elongate plumose setae; endopod three-fourths length and subequal in width to exopod. Copulatory stylet of pleopod 2 endopod with groove widening distally into hollowed area.

Remarks

Microarcturus longispinus resembles *M. rugosus* Nordenstam, 1933, in possessing elongate conical processes on the head, pereon, and pleon. The Antarctic species, however, has two elongate terminal pleotelsonic spines, unlike the single elongate posterior half of the pleotelson of the present species.

Etymology

The specific name is derived from the elongate spines on the head, pereon, and pleon seen in both the male and female.

Microarcturus nordenstami sp. nov.

Fig. 17

Material

East London area. Holotype SAM–A17812, SM 185, 33°39′S 27°11′E, 90 m, 1 ovig. ♀, TL 6,9 mm; allotype, 1 ♂, TL 5,4 mm. Paratypes SAM–A17813, SM 185, 90 m, 8 ♂, 8 ovig. ♀, 4 ♀, 9 juvs. Paratype SAM–A17814, SM 163, 33°04′S 28°06′E, 90 m, 1 ovig. ♀. Paratype SAM–A17815, SM 226, 32°28′S 28°58′E, 710–775 m, 1 ♂. Paratypes USNM 189074, SM 185, 90 m, 4 ♂, 4 ovig. ♀.

Diagnosis

Dorsolateral eyes large, well pigmented. Integument highly ornamented, with numerous rounded and acute granulate tubercles. Female with heavy granulate tripartite supraocular ridge. Pereonites 2–3 each with two strong

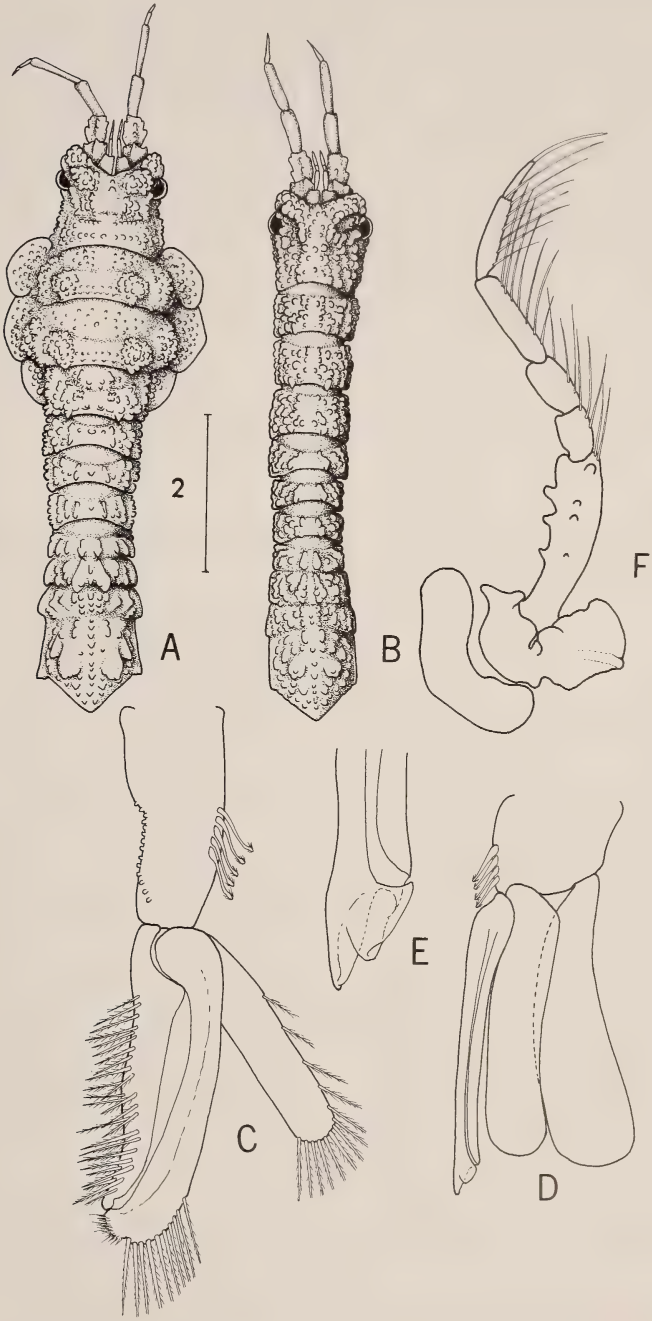

Fig. 17. *Microarcturus nordenstami* sp. nov. A. Female, dorsal view. B. Male, dorsal view. C. Pleopod 1 male. D. Pleopod 2 male. E. Apex of copulatory stylet. F. Pereopod 1. Scale = 2 mm.

submedian granulate bosses. Tubercles on anterior pleon becoming elongate; pleotelson with two strong acute submedian granulate bosses, strong lateral angle, apically acute. Male with strong granulate supraocular ridge, not markedly tripartite; submedian bosses on pleotelson not as large as in female. Epimera of pereonites 2–4 rounded in female. Pereopods 2–4 in female with bases armed with two rows of spinose tubercles; coxae expanded posteromesially over lateral marsupium into broad tuberculate structure. Pleopod 1 ♂ with distal margin rounded, with ten elongate plumose setae; gently rounded, finely setulose lobe between plumose setae and end of groove; endopod five-sixths length of and about half width of exopod. Copulatory stylet of pleopod 2 exopod tube-like, distally bilobed.

Remarks

See *Remarks* section at end of *M. barnardi.*

Etymology

The species is named for the late Dr A. Nordenstam who contributed much knowledge to isopod systematics.

Microarcturus ornatus Kensley, 1975

Fig. 18

Microarcturus ornatus Kensley, 1975*a*: 50, fig. 7; 1978*a*: 133; 1978*e*: 28, fig. 12C–E.

Material

Agulhas Bank. Holotype SAM–A13546, 200 m, 1 ovig. ♀; allotype, 1 ♂. Paratypes SAM–A13547, 200 m, 2 ♂.

Transkei. SAM–A17816, SM 228, 650–700 m, 5 ♂. SAM–A17817, SM 236, 660–670 m, 1 ♂. SAM–A17818, SM 250, 150–200 m, 6 ♂.

Diagnosis

Integument granular-tuberculate. Pereonites 2–4 in female with pair of submedian flattened and produced tubercles, and one pair smaller lateral tubercles; epimera of pereonite 2 semicircular, of pereonite 3 triangular. Pereonites 5–7 and pleonites 1–3 with short ridge-like tubercles. Male with large produced submedian pair of tubercles on pereonite 2 only. Pleonite 2 with strong apically acute 'shoulders', much less prominent in male than in female. Pereopods 2–4, coxae with acutely triangular, posteriorly directed process; bases armed with acute spinose processes on anterior margin in female only. Pereopods 5–7 with single spinose process on outer margin of bases in male and female. Pleopod 1 ♂ with distal margin convex, bearing ten elongate plumose setae; groove opening distally on somewhat convoluted, finely setulose lobe, separated by distinct cleft from distal setose lobe; endopod about five-sixths length and half width of exopod. Copulatory stylet of pleopod 2 endopod distally bilobed.

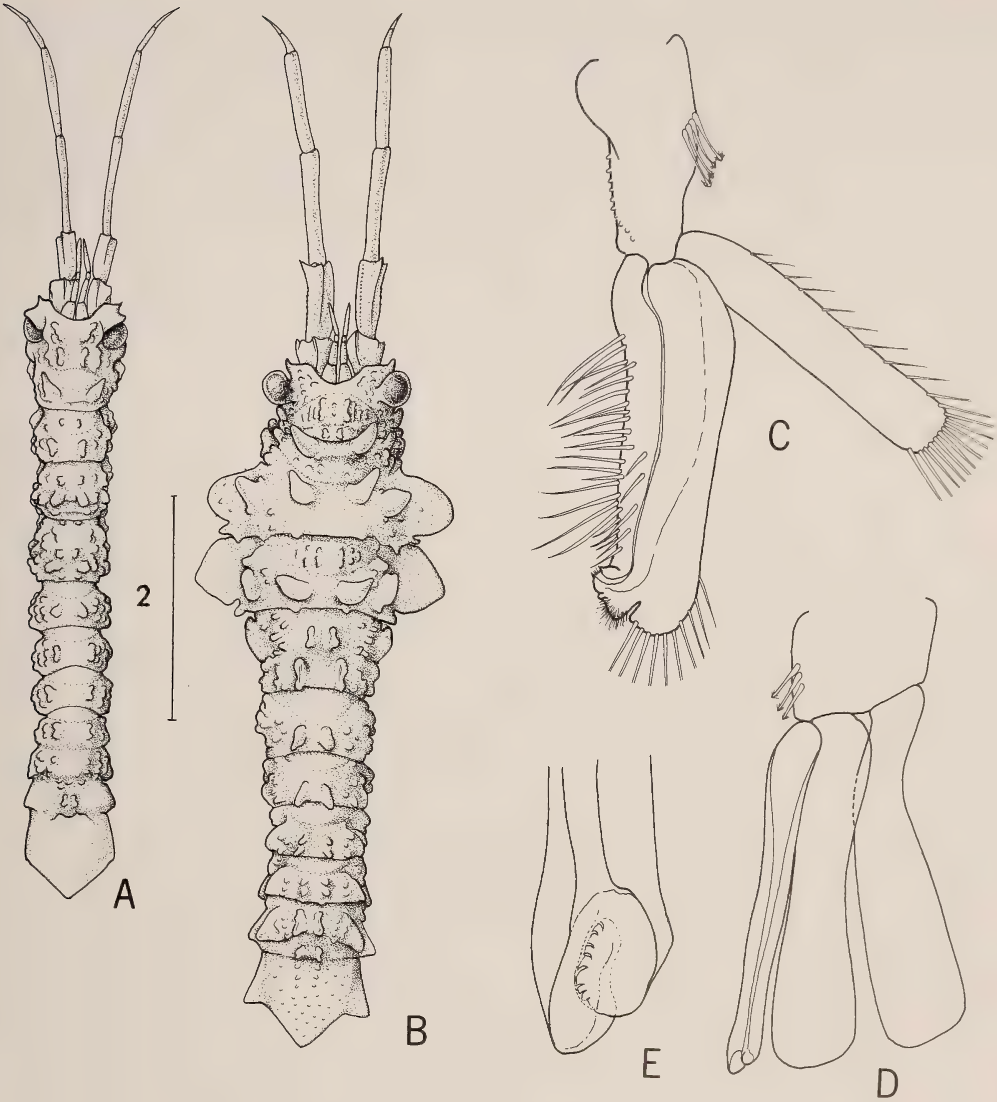

Fig. 18. *Microarcturus ornatus* Kensley A. Male, dorsal view. B. Female, dorsal view. C. Pleopod 1 male. D. Pleopod 2 male. E. Apex of copulatory stylet. Scale = 2 mm.

Microarcturus oudops (Barnard, 1914)

Fig. 19

Neoarcturus oudops Barnard, 1914: 214, pl. 28C, pl. 29B; 1920: 397; 1940: 508. Nordenstam, 1933: 115.
Microarcturus oudops: Kensley, 1978*a*: 130, fig. 3; 1978*e*: 28, fig. 13A.

Material

Cape Point area. Holotype SAM–A69, 1 510 m, 1 ♂, (damaged). SAM–A4070, 1 400 m, 16 ♂, 4 ovig. ♀, 1 ♀, 16 juvs. SAM–A14027, (no locality data), 2 ♂, 1 ovig. ♀, 2 juvs.

Zululand to Transkei area. SAM–A17819, SM 103, 680 m, 2 ♂, 4 ovig. ♀, 4 juvs. SAM–A17820, SM 129, 850 m, 4 ♂, 2 ovig. ♀, 1 juv. SAM–A17821, SM 226, 710–775 m, 7 ♂, 6 ovig. ♀. SAM–A17822, SM 228, 650–700 m, 5 ♂, 1 ovig. ♀. SAM–A17823, SM 236, 660–670 m, 1 ♂, 1 juv.

Diagnosis

Integument finely granulate. Head with rounded granular eyes lacking pigment or ommatidia. Pereonites 1–4 each with small anterior and large posterior transverse granulate ridge; epimera 2–4 in female shallowly triangular; coxal processes narrowly triangular, pereopods 2–4 unarmed. Pleonite 1 short, ridge-like; pleonite 3 somewhat inflated in male. Pleotelson with well-developed lateral angle in male, present or absent in female; posterior margin broadly angular to rounded. Pleopod 1 ♂, exopod with rounded distal margin bearing five plumose setae, divided by narrow cleft from elongate-rounded setulose lobe distal to end of groove; endopod slightly more than half length and half width of exopod, sparsely setose. Pleopod 2 ♂, copulatory stylet distally bilobed and convoluted.

Microarcturus quadriconus Kensley, 1975

Fig. 20

Microarcturus quadriconus Kensley, 1975*a*: 52, fig. 8; 1978*e*: 28, fig. 13B–C.

Material

False Bay. SAM–A13777, 31 m, 2 ♂. SAM–A13839, 53 m, 3 ♂, 1 ovig. ♀. SAM–A13848, 22 m, 1 juv. SAM–A13850, 33 m, 1 ♂, 4 ovig. ♀. SAM–A13873, 39 m, 1 ♂, 1 ovig. ♀, 3 juvs. SAM–A13875, 40 m, 1 ♂, 5 ovig. ♀. SAM–A13876, 39 m, 2 ovig. ♀. SAM–A13904, 75 m, 1 ovig. ♀. SAM–A13905, 40 m, 1 ovig. ♀, 1 juv. SAM–A17867, 3 ♂, 2 ovig. ♀, 1 ♀, 1 juv.

Agulhas Bank. Holotype SAM–A13548, 80 m, 1 ovig. ♀; allotype, 1 ♂. Paratypes SAM–A13549, 80 m, 2 ovig. ♀.

East London area. SAM–A17824, SM 179, 80 m, 2 ♂, 5 ovig. ♀. SAM–A17825, SM 180, 80 m, 8 ♂, 12 ovig. ♀, 1 ♀, 22 juvs.

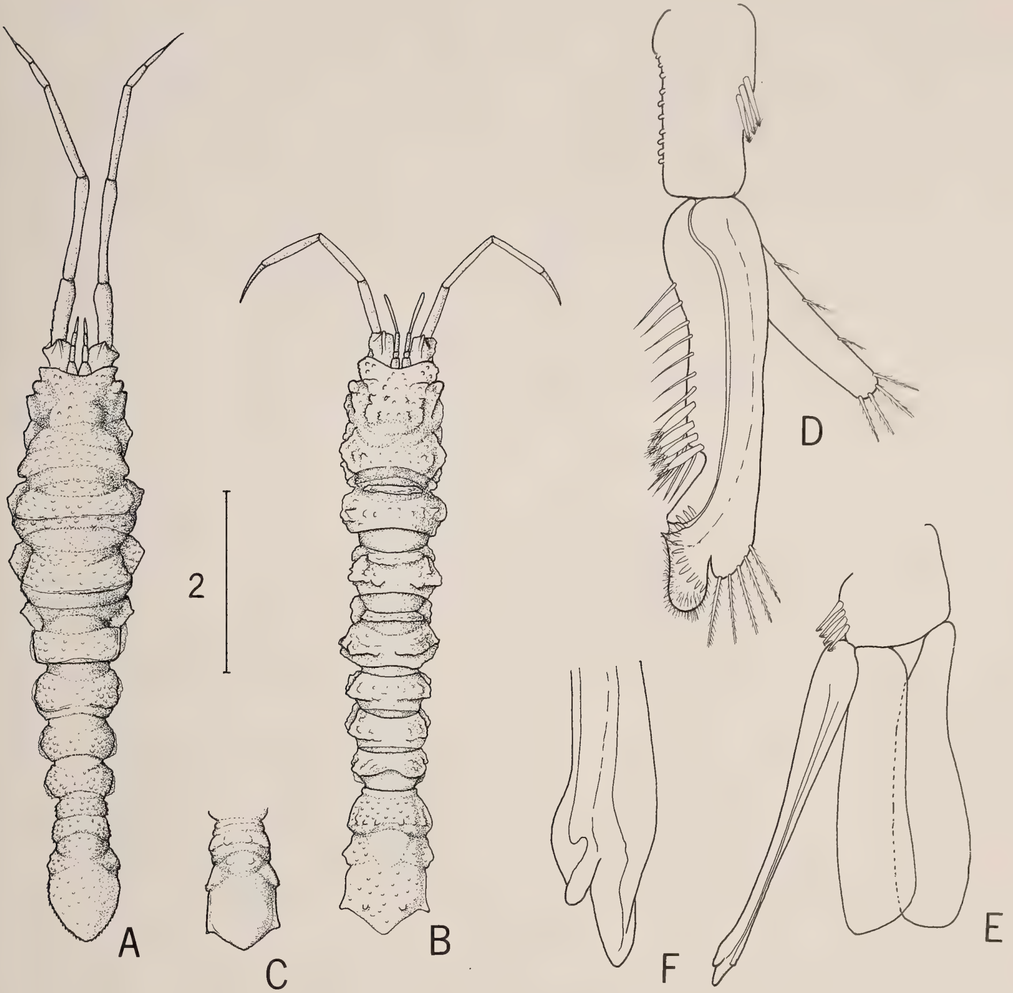

Fig. 19. *Microarcturus oudops* A. Female, dorsal view. B. Male, dorsal view. C. Pleotelson, dorsal view. D. Pleopod 1 male. E. Pleopod 2 male. F. Apex of copulatory stylet. Scale = 2 mm.

Diagnosis

Integument smooth, lacking scattered small tubercles; with low conical processes, two on head, four on pereonites 1–4 each, two on pereonite 5, becoming obsolete posteriorly; middorsal rounded tubercle at base of pleotelson. Epimera 2 and 3 triangular, subacute in male and female. Pleotelson pentagonal, lateral angles more marked in female than in male. Pleopod 1 ♂, exopod very similar to that of *Microarcturus similis* and *M. dayi*; endopod subequal in length and width to exopod. Copulatory stylet as in *M. similis* and *M. dayi*, apically simple.

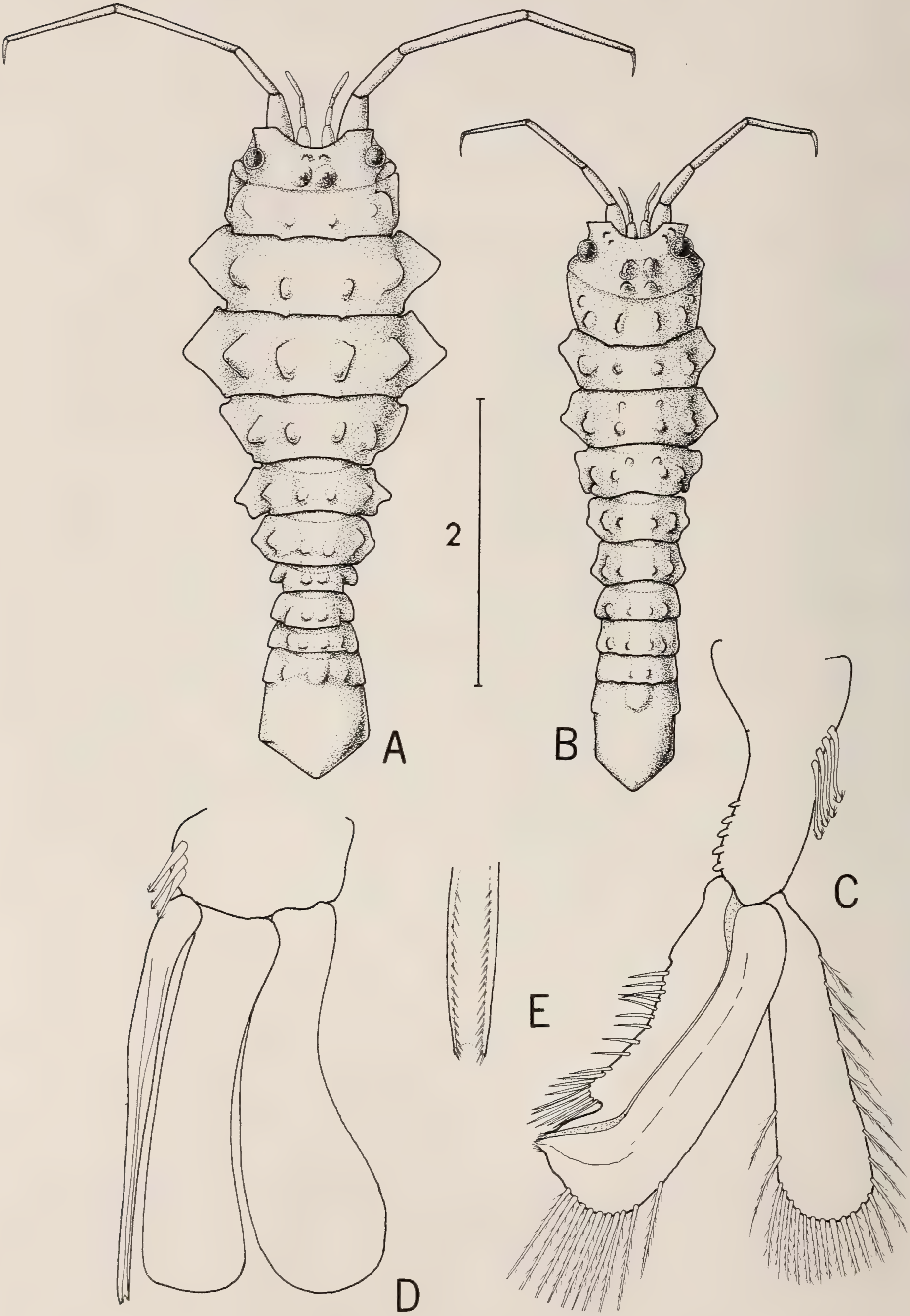

Fig. 20. *Microarcturus quadriconus* Kensley A. Female, dorsal view. B. Male, dorsal view. C. Pleopod 1 male. D. Pleopod 2 male. E. Apex of copulatory stylet. Scale = 2 mm.

Remarks

This species has been taken from twelve stations from False Bay to East London, sometimes co-occurring with *M. similis*. There is a possibility that this is another form of the variable *M. similis*, but even in the smoothest forms of the latter species there are always fairly strong submedian ridges. These have not been seen in *M. quadriconus*; similarly, strongly rounded and conical tubercles have not been noted in *M. similis*.

Microarcturus similis (Barnard, 1925)

Figs 21–22

Antarcturus similis Barnard, 1925: 395, fig. 1; 1940: 508.
Microarcturus similis: Nordenstam, 1933: 128. Kensley, 1975*a*: 47, figs 5a–b; 1978*a*: 133; 1978*e*: 31, fig. 13D–E.

Material

Lüderitz. SAM–A13902, 35 m, 3 ♂.

Saldanha Bay area. SAM–A13778, 15 m, 1 ♀. SAM–A13781, 44 m, 1 ♂, 1 ovig. ♀, 1 ♀, 8 juvs. SAM–A13782, 44 m, 2 ♂, 2 ovig. ♀, 1 ♀, 1 juv. SAM–A13863, 68 m, 1 ♂, 1 juv. SAM–A13864, 65 m, 6 ♂, 3 ovig. ♀, 3 ♀, 6 juvs. SAM–A13865, 78 m, 1 ♂, 1 ovig. ♀. SAM–A13866, 62 m, 3 ♂. SAM–A13867, 51 m, 1 ovig. ♀. SAM–A13868, 78 m, 1 ♂, 1 juv. SAM–A13869, 42–51 m, 26 ♂, 10 ovig. ♀, 8 ♀, 64 juvs. SAM–A13870, 71 m, 1 juv.

False Bay. SAM–A13776, 38 m, 1 ♂, 1 juv. SAM–A13769, 60 m, 3 ♂, 2 ovig. ♀. SAM–A13775, 75 m, 6 ♂, 2 ovig. ♀, 1 juv. SAM–A13838, 64 m, 1 ♂, 1 juv. SAM–A13840, 33 m, 1 ovig. ♀. SAM–A13841, 66 m, 4 ♂, 8 ovig. ♀, 3 ♀, 11 juvs. SAM–A13842, 71 m, 1 juv. SAM–A13844, 36 m, 1 ♂, 1 ♀. SAM–A13845, 42 m, 1 juv. SAM–A13846, 33 m, 1 ♂. SAM–A13847, 33 m, 5 ♂, 3 ovig. ♀. SAM–A13851, 36 m, 1 ♀. SAM–A13853, 53 m, 1 ♂. SAM–A13854, 60 m, 2 ♂, 1 ♀. SAM–A13855, 87 m, 1 ♂, 2 juvs. SAM–A13856, 73 m, 1 ♂. SAM–A13857, 87 m, 2 ♂, 1 ovig. ♀, 1 ♀, 5 juvs. SAM–A13858, 48 m, 4 ♂, 1 ovig. ♀, 3 juvs. SAM–A13859, 87 m, 23 ♂, 14 ovig. ♀, 8 ♀, 20 juvs. SAM–A13860, 31 m, 3 ♂, 2 ovig. ♀, 4 ♀. SAM–A13861, 1 ovig. ♀. SAM–A13862, 26 m, 1 ♂, 1 ovig. ♀. SAM–A13871, 68 m, 2 ♂, 1 juv. SAM–A13872, 40 m, 1 juv. SAM–A13874, 48 m, 1 juv. SAM–A13877, 41 m, 1 ♀. SAM–A13878, 68 m, 1 ovig. ♀, 1 juv. SAM–A13880, 31 m, 4 ♂, 1 ♀. SAM–A13881, 73 m, 1 ovig. ♀. SAM–A13882, 31 m, 1 ♀. SAM–A13896, 28 m, 1 ♂, 1 juv. SAM–A13897, 75 m, 19 ♂, 8 ovig. ♀, 4 ♀, 10 juvs. SAM–A13898, 1 ♀. SAM–A13903, 80 m, 1 ♂, 1 ♀, 1 juv. SAM–A17826, 87 m, 1 ♂, 1 juv. SAM–A17827, 66 m, 1 ♂. SAM–A17828, 40 m, 4 ♂, 4 ovig. ♀, 7 ♀, 5 juvs.

Agulhas Bank. Syntypes SAM–A5951, 84 m, 1 ovig. ♀, 1 ♀. SAM–A5953, 86 m, 1 ♂. SAM–A5954, 80 m, 2 ♀. SAM–A13765, 50 m, 1 ♂. SAM–A13766, 50 m, 1 ovig. ♀. SAM–A13767, 50 m, 1 ♀. SAM–A13884, 79 m, 3 ♂, 2 ovig. ♀. SAM–A13885, 49 m, 1 ovig. ♀, 1 juv. SAM–A13886, 44 m, 4 ♂, 4 ovig. ♀, 1 ♀. SAM–A13887, 73 m, 1 ♂, 1 juv. SAM–A13888, 48 m, 1 juv. SAM–A13889, 42 m, 4 ♂, 4 ovig. ♀, 2 ♀, 1 juv. SAM–A13890, 36 m, 1 ovig. ♀. SAM–A13891, 78 m, 2 juvs. SAM–A13892, 32 m, 2 ♀. SAM–A13893, 45 m, 1 ovig. ♀. SAM–A13894, 46 m, 1 ovig. ♀. SAM–A13901, 43 m, 1 ovig. ♀.

Diagnosis

Integumental sculpturing varying from very granular to almost smooth, in all cases with double submedian dorsal series of elongate ridge-like tubercles on head, pereonites, and three fused pleonites. Epimera of pereonites 2–4, especially in female, broadly triangular, subacute. Pleotelson pentagonal, with distinct lateral angle. Bases of pereopods 2–4 unarmed in male and female. Pleopod 1 ♂, exopod distally rounded, with nine plumose setae, area between setose distal margin and end of groove almost straight; endopod subequal in length and width to exopod. Copulatory stylet of pleopod 2 endopod distally simple, open, gutter-like.

Remarks

Barnard (1925) remarked on the superficial similarity of his species to *Arcturus simplicissimus* Whitelegge, 1904, but noted that the antennae differed markedly. *Arcturus stebbingi* Beddard, 1886, which Barnard also mentioned, is unmistakably an *Antarcturus*, with very elongate antennae, anterior 'horns' on the head, and strong submedian spines on the pleon, and bears little resemblance to *M. similis*.

Barnard's syntypic material of this species (SAM–A5951) is a mixture of two specimens of *M. similis* and several specimens of *M. dayi*, hence his remarks on the variability of the tubercles (1925: 396).

Microarcturus youngi Kensley, 1978

Fig. 23

Microarcturus youngi Kensley, 1978*a*: 131, fig. 4; 1978*e*: 31, fig. 13E–G.

Material

Zululand to Transkei area. Holotype SAM–A15465, SM 86, 550 m, 1 ovig. ♀, TL 5,8 mm; allotype, 1 ♂, TL 6,0 mm. Paratypes SAM–A15466, SM 103, 680 m, 8 ♂, 10 ♀, 37 juvs. Paratypes SAM–A17829, SM 86, 550 m, 12 ♂, 5 ♀, 3 ovig. ♀, 50 juvs. SAM–A17830, SM 123, 690 m, 1 ♂. SAM–A17831, SM 129, 850 m, 3 ♂, 2 juvs. SAM–A17832, SM 226, 710–775 m, 4 ♂, 2 ovig. ♀, 1 juv.

Diagnosis

Eyes well pigmented. Integumental sculpturing varying, especially in male, from relatively smooth to having small scattered granules. Epimera of pereonites 2–3 in female laterally rounded to bluntly triangular. Pereonites 2–3 with

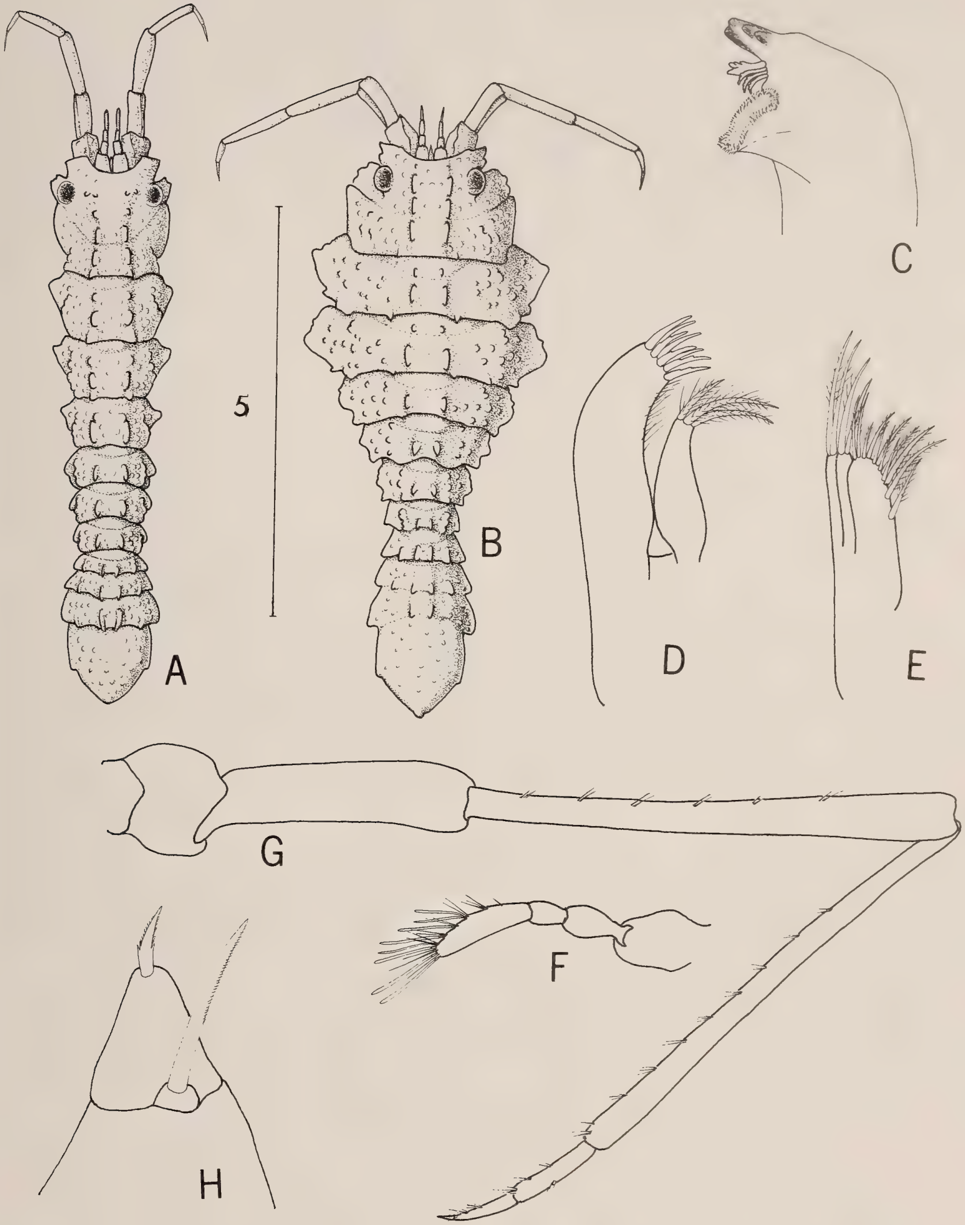

Fig. 21. *Microarcturus similis* (Barnard) A. Male, dorsal view. B. Female, dorsal view. C. Mandible. D. Maxilla 1. E. Maxilla 2. F. Antennule. G. Antenna. H. Uropodal rami. Scale = 5 mm.

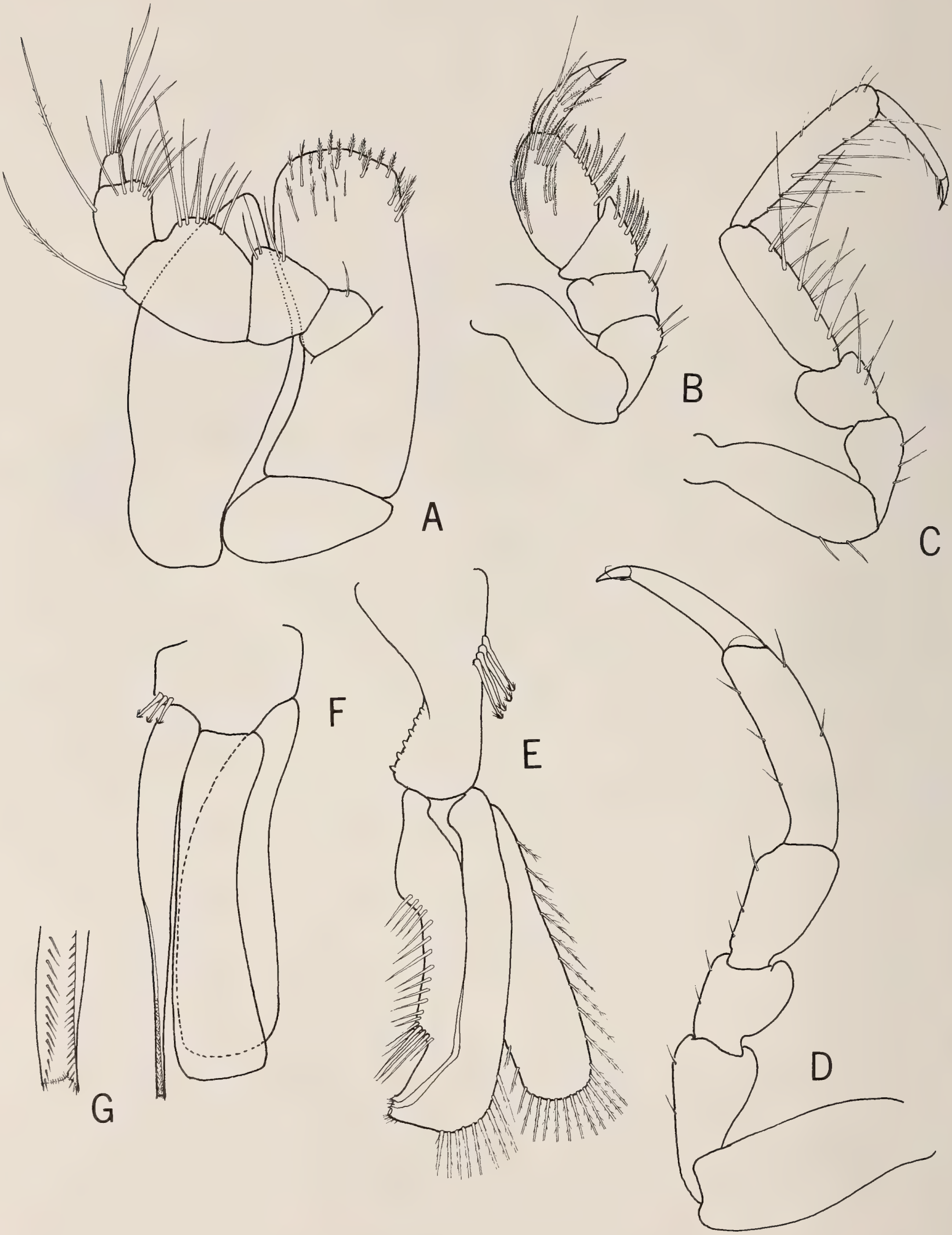

Fig. 22. *Microarcturus similis* (Barnard) A. Maxilliped. B. Pereopod 1. C. Pereopod 2. D. Pereopod 7. E. Pleopod 1 male. F. Pleopod 2 male. G. Apex of copulatory stylet.

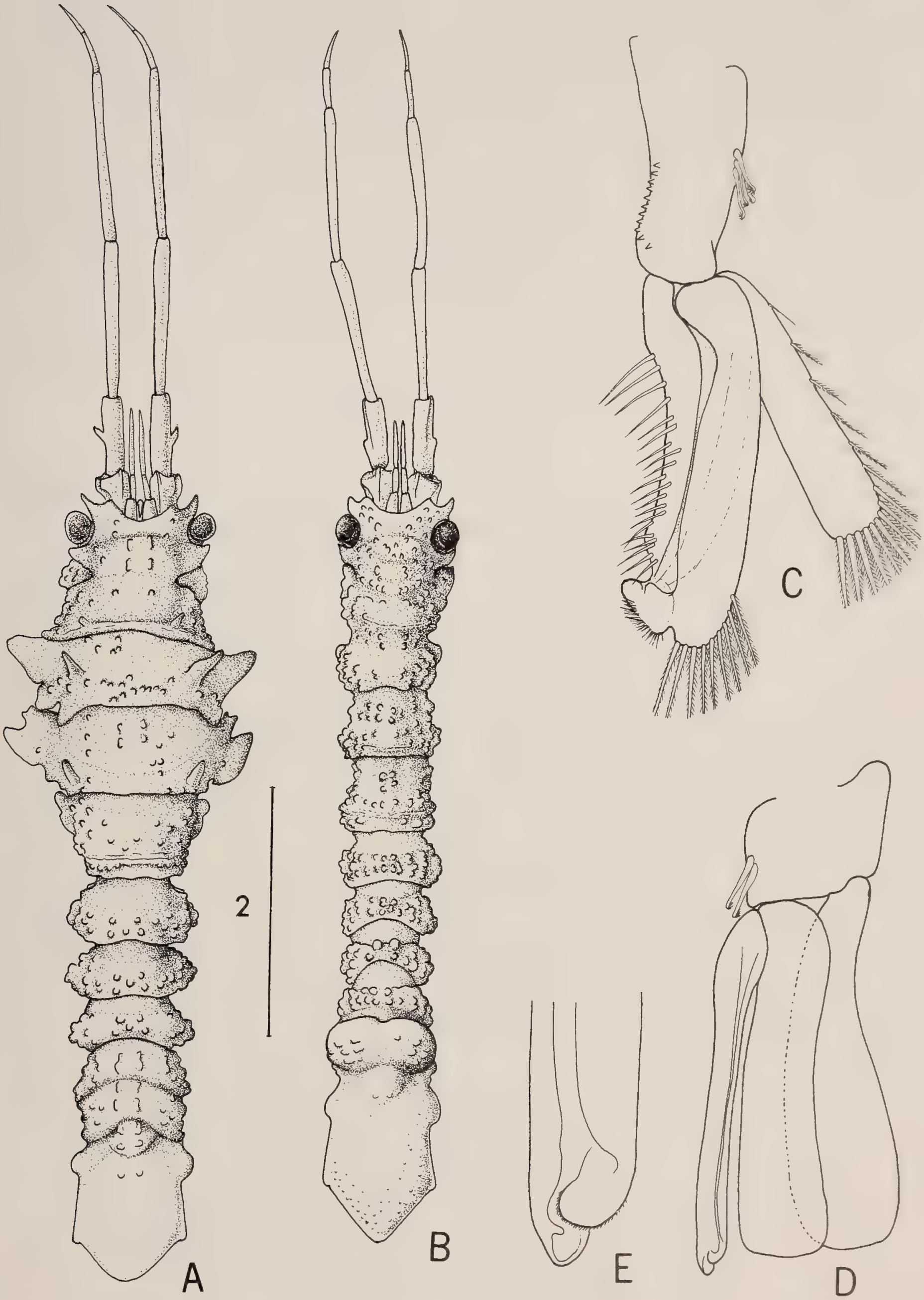

Fig. 23. *Microarcturus youngi* Kensley A. Female, dorsal view. B. Male, dorsal view. C. Pleopod 1 male. D. Pleopod 2 male. E. Apex of copulatory stylet. Scale = 2 mm.

dorsolateral tubercle sometimes spiniform. Pleotelson pentagonal, with distinct lateral angle; basal fused pleonite in male somewhat inflated, dorsally bipartite. Pleopod 1 in male, exopod distally rounded, with nine plumose setae, distinct notch between setae and distal lobe; endopod about two-thirds length of exopod. Copulatory stylet of pleopod 2 distally bilobed.

INFRAORDER FLABELLIFERA

Family **Cirolanidae**

Cirolana Leach, 1818

Cirolana anocula nom. nov.

Fig. 24

Cirolana caeca (*non* Dollfus, 1903), Kensley, 1978*a*: 141, figs 11–12.
Metacirolana caeca: Bruce, 1981: 954.

Material

Transkei. SAM–A17833, SM 123, 690 m, 2 ovig. ♀, 3 ♀, 3 juvs. USNM 189075, SM 129, 850 m, 5 ♂, 5 ovig. ♀, 3 ♀, 6 juvs.

Previous records

Off Zululand, 750 m.

Remarks

Kensley (1978*a*) created a homonym for this species, being unaware of *Cirolana caeca* Dollfus, 1903, described from 1 200–2 368 m in the Mediterranean. This situation is corrected here. From Dollfus's description, *C. caeca*

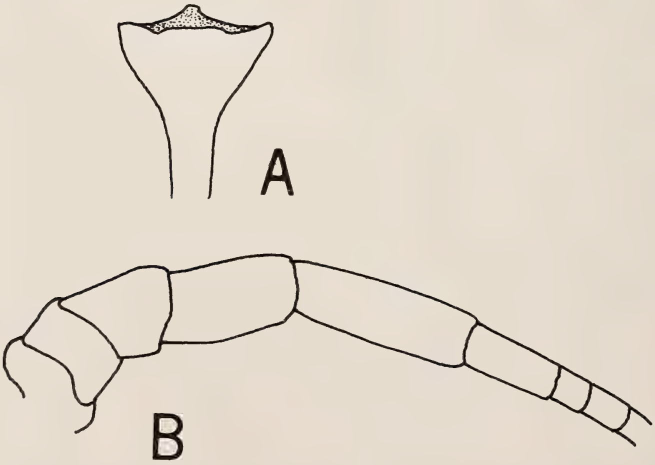

Fig. 24. *Cirolana anocula* nom. nov. A. Frontal lamina. B. Peduncle of antenna.

differs from *C. anocula* in having a narrow, longitudinally grooved frontal lamina, and in being a much larger species (TL ovig. ♀ 9,0 mm).

Bruce (1981) includes the present species in the genus *Metacirolana. Cirolana anocula*, however, does not agree entirely with the diagnosis of *Metacirolana* provided by Bruce (1981: 950). While the distally divergent frontal lamina and downward-projecting clypeus agree, the endopod of maxilla 1 is neither slender nor sparsely setose, while pleonite 5 lacks free lateral margins and is definitely overlapped by pleonite 4. All pleonite rami, except the endopod of pleopod 5, bear plumose setae, as is the case for both *Cirolana* and *Metacirolana*. For these reasons, the species is left in *Cirolana*.

The antenna, which was incorrectly figured in the original description, is again provided, along with the frontal lamina.

Cirolana bougaardti sp. nov.

Figs 25–26

Material

East London to Transkei area. Holotype SAM–A17834, SM 226, 32°28′S 28°58′E, 710–775 m, 1 ♂, TL 17,0 mm. Paratype SAM–A17835, SM 162, 32°55′S 28°31′E, 630 m, 1 ♂, TL 11,0 mm.

Description

Male

Body about three times longer than wide, dorsally strongly convex. Integument faintly pitted. Head with anterior margin evenly rounded, posteriorly immersed in pereonite 1. Frontal lamina basally narrow, distally dilated, rounded. Clypeus transversely narrowly rectangular. Eyes absent. Pereonite 1 with incomplete dorsolateral incised line in anterior half; pereonites 2–7 with complete incised line across anterior half of dorsum. Coxae of pereonites 2–4 posteroventrally rounded, becoming produced posteriorly; coxa of pereonite 5 subacute, of pereonites 6 and 7 acute. Short rounded submedian penial processes on pereonite 7. Pleonites 1–3 with acute posteroventral angle, pleonite 3 laterally overlapping pleonite 4; pleonite 5 lacking free lateral margins, overlapped by pleonite 4. Pleotelson posteriorly evenly rounded, dorsally gently convex, posterior margin setose.

Antennule reaching posteriorly to middle of pereonite 1; article 3 of peduncle longer than articles 1 and 2 together; flagellum of twelve articles. Antenna reaching posteriorly to pereonite 3; peduncle article 5 longest; flagellum of about twenty-eight articles. Mandibular palp with article 2 longest, armed with cluster of simple and fringed spines distally; article 3 strongly curved, with inner margin bearing row of spines, becoming distally longer; incisor of three sclerotized cusps; spine row of about thirteen spines; molar with about twenty-eight teeth. Maxilla 1, outer ramus with twelve distal spines, inner ramus with three stout plumose setae. Maxilla 2, inner ramus with numerous simple and fringed

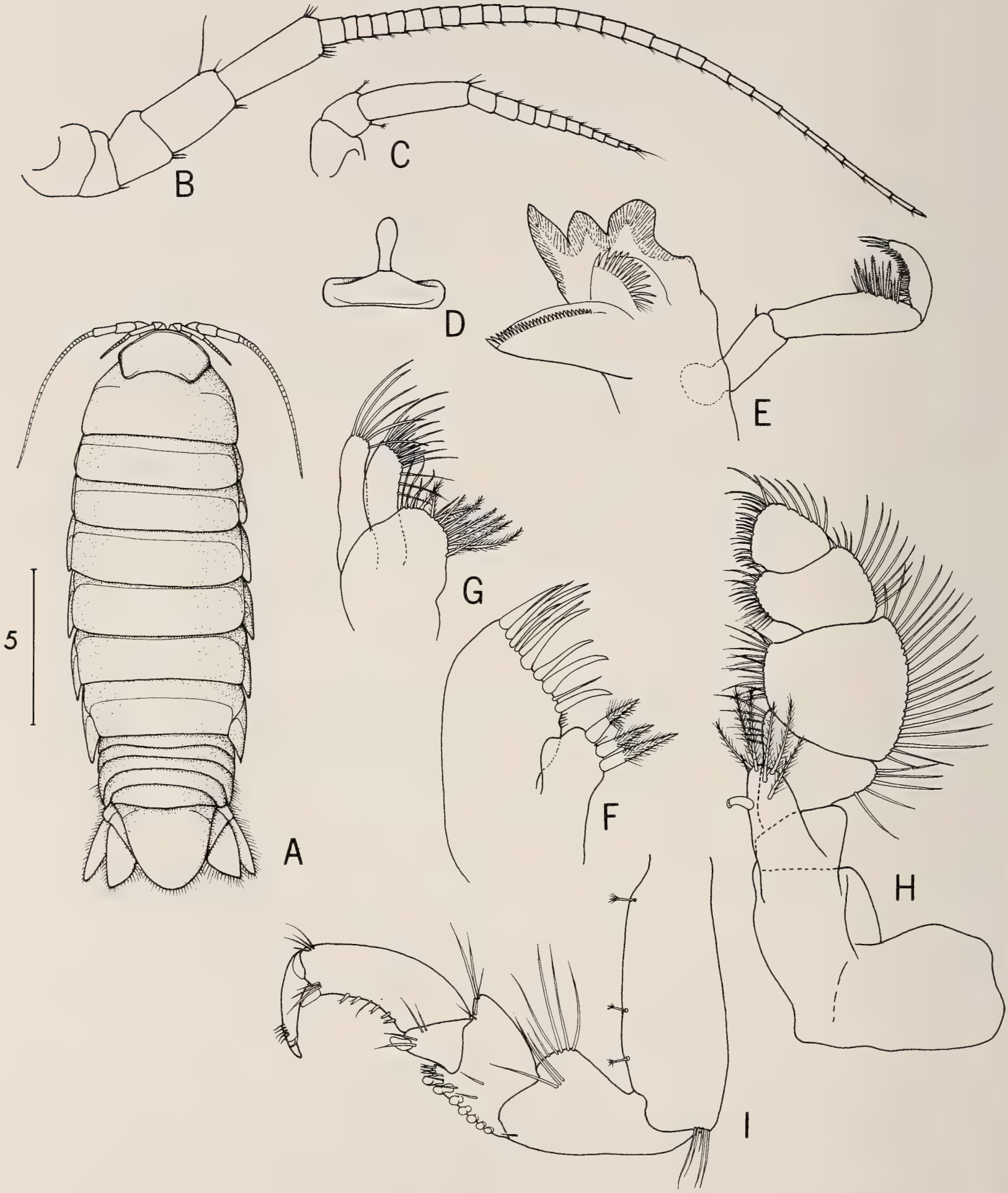

Fig. 25. *Cirolana bougaardti* sp. nov. A. Holotype male, dorsal view. B. Antenna. C. Antennule. D. Frontal lamina and clypeus. E. Mandible. F. Maxilla 1. G. Maxilla 2. H. Maxilliped. I. Pereopod 1. Scale = 5 mm.

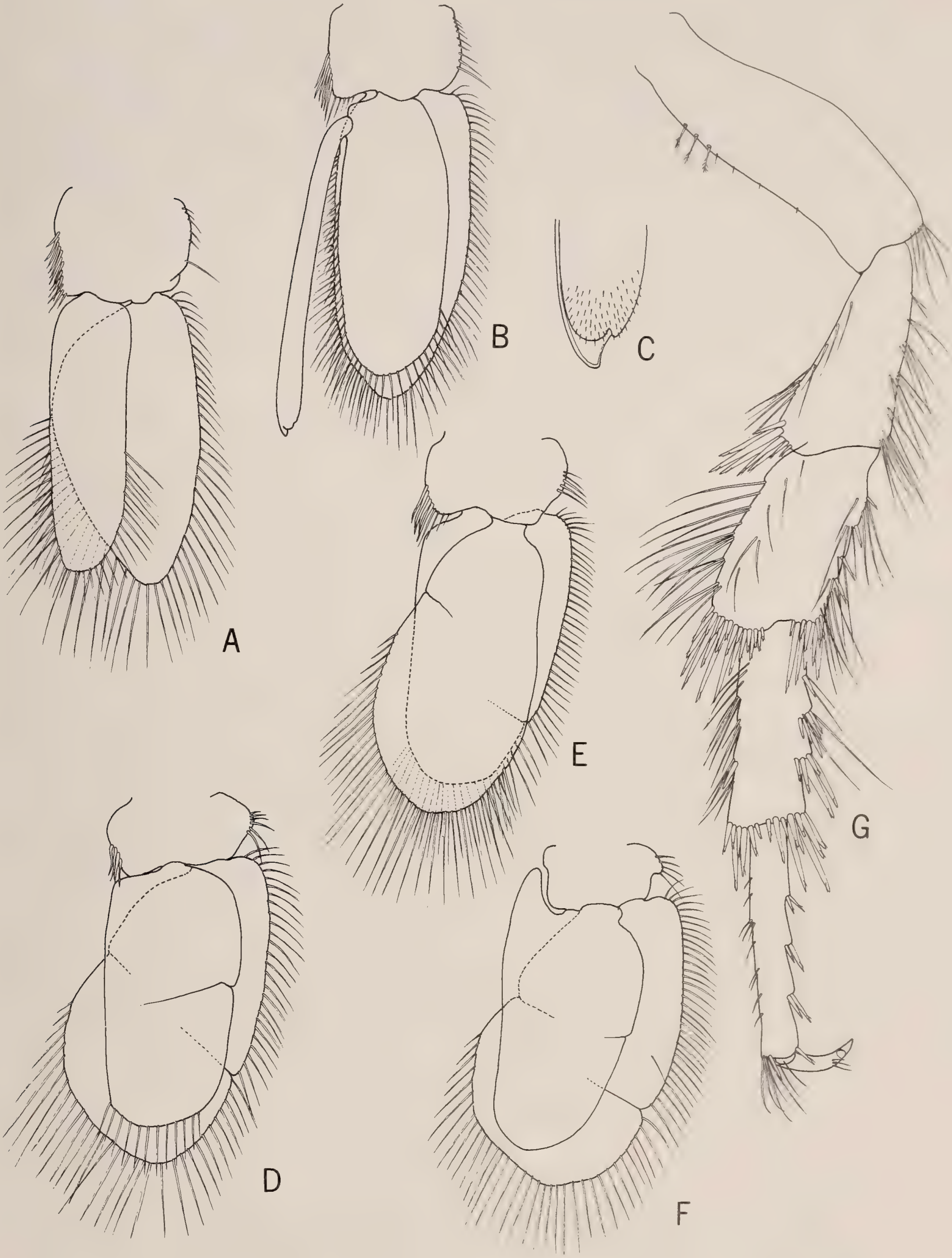

Fig. 26. *Cirolana bougaardti* sp. nov. A. Pleopod 1. B. Pleopod 2 male. C. Apex of copulatory stylet. D. Pleopod 3. E. Pleopod 4. F. Pleopod 5. G. Pereopod 7.

spines on mediodistal margin; inner lobe of outer ramus with dense cluster of short and long spines; outer lobe with six elongate spines. Maxilliped endite with single coupling hook, six fringed setae distally; palp with elongate setae on outer margins of all five articles; shorter setae on medial margins of four distal articles, article 3 broadest and longest. Pereopods 1–3 shorter than following legs, prehensile, with curved propodi bearing strong blunt posterodistal spine and few short sensory spines on posterior margin; carpus short, triangular, with single strong blunt posterodistal spine; merus with setose/spinose distodorsal lobe, row of stout rounded peg-like spines along posterior margin; ischium distally expanded. Pereopods 4–7 elongate, ambulatory; propodus straight, rectangular, with three clusters of sensory spines on posterior margin; carpus triangular, bearing elongate setae on anterior margin, clumps of sensory spines on posterior margin, and row of short and long spines on distal margin; merus with anterior setae, posterior setae and spines, clumps of short and long sensory spines at anterodistal and posterodistal corners; ischium with clumps of spines on anterodistal corner. Pleopods with all rami except endopod of pleopod 5 bearing marginal plumose setae. Pleopod 1, endopod half width of exopod, subequal in length. Pleopod 2 with copulatory stylet articulating basally on endopod, rod-like, reaching well beyond rami, distally lobed; endopod slightly narrower and shorter than exopod. Pleopods 3–5 with exopod becoming distally more broadly rounded. Uropodal basis produced along medial margin of endopod; laterally distally broadened, apically narrowly rounded; exopod about half width, subequal in length to endopod, distally narrowly rounded.

Remarks

Of the very few blind deep-sea species of *Cirolana* recorded, *C. bougaardti* most closely resembles *C. californiensis* Schultz, 1966, from 812 m in the Coronado Canyon off southern California. The American species differs from the South African species in the posteriorly acute pleotelson, lack of a dorsal incised line on the pereonites, in the very short antennule, the distally acute frontal lamina, as well as in several details in the mouth-parts.

Etymology

The species is named for Michael Bougaardt, in thanks for his assistance both on the *Meiring Naude* cruises and in the Department of Marine Biology at the South African Museum.

Cirolana convexissima sp. nov.

Figs 27–28

Material

Transkei area. Holotype SAM–A17836, SM 250, 31°59′S 29°22′E, 150–200 m, 1 ovig. ♀, TL 3,3 mm. Paratypes SAM–A17837, SM 250, 150–200 m, 1 ♂, TL 2,6 mm, 4 juvs. Paratypes USNM 189076, SM 250, 150–200 m, 1 ♂, TL 2,6 mm, 1 ovig. ♀, TL 3,3 mm, 3 juvs.

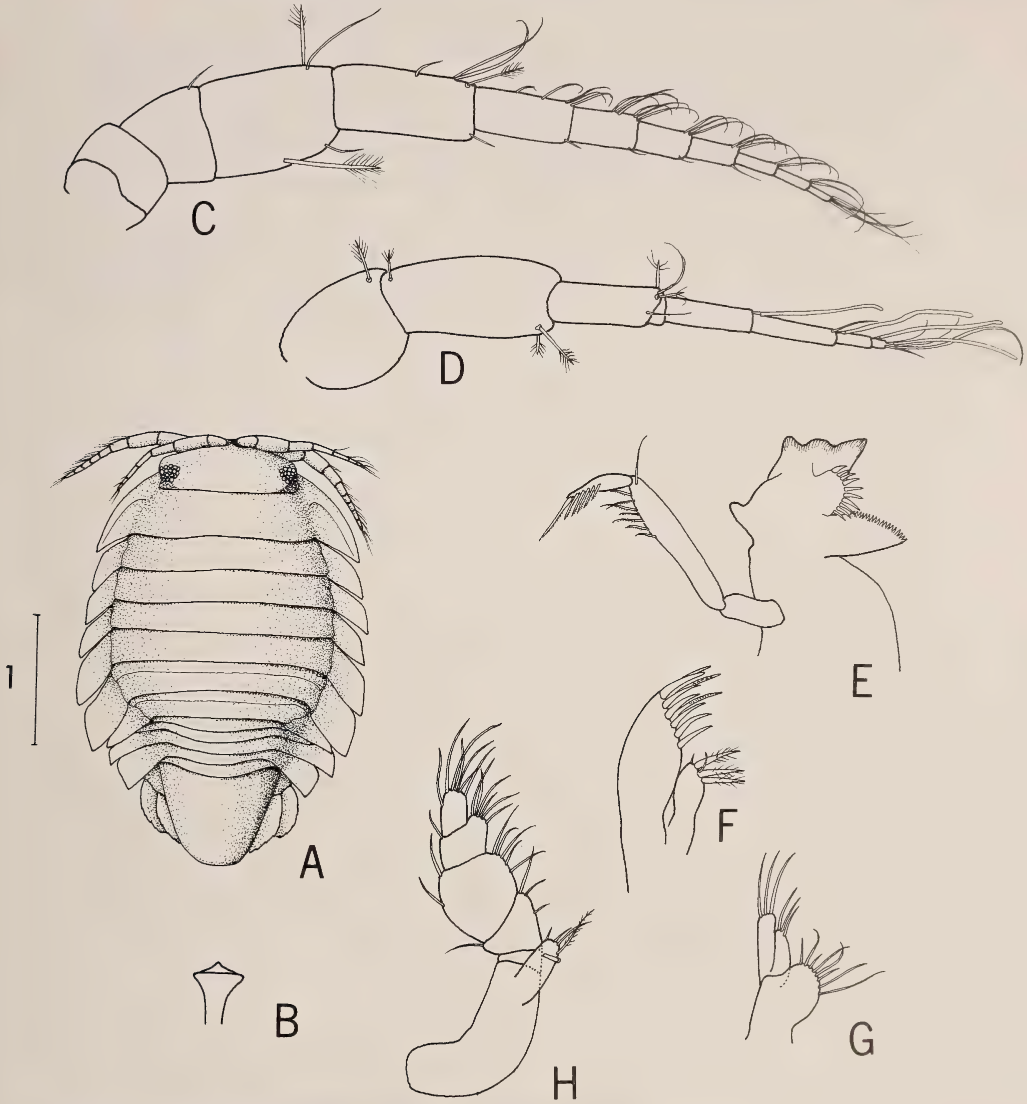

Fig. 27. *Cirolana convexissima* sp. nov. A. Male, dorsal view. B. Frontal lamina. C. Antenna. D. Antennule. E. Mandible. F. Maxilla 1. G. Maxilla 2. H. Maxilliped. Scale = 1 mm.

Description

Male

Body dorsally strongly convex, widest at pereonite 5. Head with tiny rostral point, only partially immersed in pereonite 1; with relatively well-pigmented eyes. Frontal lamina distally dilated, basally narrow. Coxae of pereonites posteriorly acute; coxa 1 with curved incised dorsal line; coxa 6 broad, rectangular, overlapping narrow coxa 7. Pereonites 6 and 7 with transverse incised line in anterior half across dorsum. Pleonite 1 with very short acute lateral margin wedged between coxa 7 and more elongate acute lateral margin of pleonite 2; lateral margin of pleonite 3 contiguous with coxa 7, half width of lateral margin of pleonite 4; pleonite 5 lacking free lateral margin. Pleotelsonic margin entire, posteriorly broadly and evenly rounded.

Antennule with article 2 longer than both article 1 or 3; flagellum of five articles, four distal articles each with single aesthetasc. Antenna with three basal peduncle articles together equal to article 4; flagellum of seven articles. Mandibular palp with article 2 almost three times length of article 1, with seven finely serrate spines distally; article 3 with six serrate spines; incisor of three cusps; spine row with ten spines. Maxilla 1, inner ramus with three stout fringed setae; outer ramus with nine simple and serrate spines. Maxilla 2, inner ramus with eight setae on rounded mediodistal margin, lobes of outer ramus each with three distal spines. Maxilliped with palp article 2 longest and broadest; setae on mediodistal corners of articles 2–5; endite with one retinaculum and four distal setae. Pereopods 1–3 similar, with propodus robust and somewhat curved. Pereopod 1, propodus with three sensory spines on posterior margin; carpus with one posterodistal spine; merus with three spines; ischium with single posterodistal spine. Pereopod 2, propodus with five sensory spines on posterior margin; merus produced distodorsally into triangular lobe bearing three stout spines. Pereopods 4–7 with propodi elongate-rectangular; clumps of sensory spines, at dorsodistal and posterodistal corner of propodi, carpi, meri, and ischia. Pleopods with all rami except endopod of pleopod 5 bearing plumose marginal setae. Pleopod 2, copulatory stylet articulating subbasally on endopod, reaching by half its length beyond rami, apically narrowly acute; exopods of pleopods 4 and 5 clearly biarticulate. Uropodal basis produced into triangular lobe along medial margin of endopod; latter broadly oval, with marginal setae; exopod three-fourths length and half width of exopod.

Remarks

The present species bears a close resemblance to *Cirolana anocula* (see p. 260), especially in overall body shape and proportions. Numerous differences, however, make separation of the two species easy, but also suggest that *C. anocula* may be a closely related species to, or even a sister-species of, *C. convexissima*, the former having found an ecological niche at greater depths and, in so doing, lost its eyes.

These afore-mentioned differences lie in the eyes (present in *C. convexissima,* absent in *C. anocula*), uropodal shape; incised lines on pereonites 6 and 7 in *C. convexissima*, coxal shape, and pleotelsonic shape. As with *C. anocula*, the frontal lamina and clypeus agree with Bruce's diagnosis of *Metacirolana,* but pleonite 5 does not have free lateral margins, and is overlapped by pleonite 4.

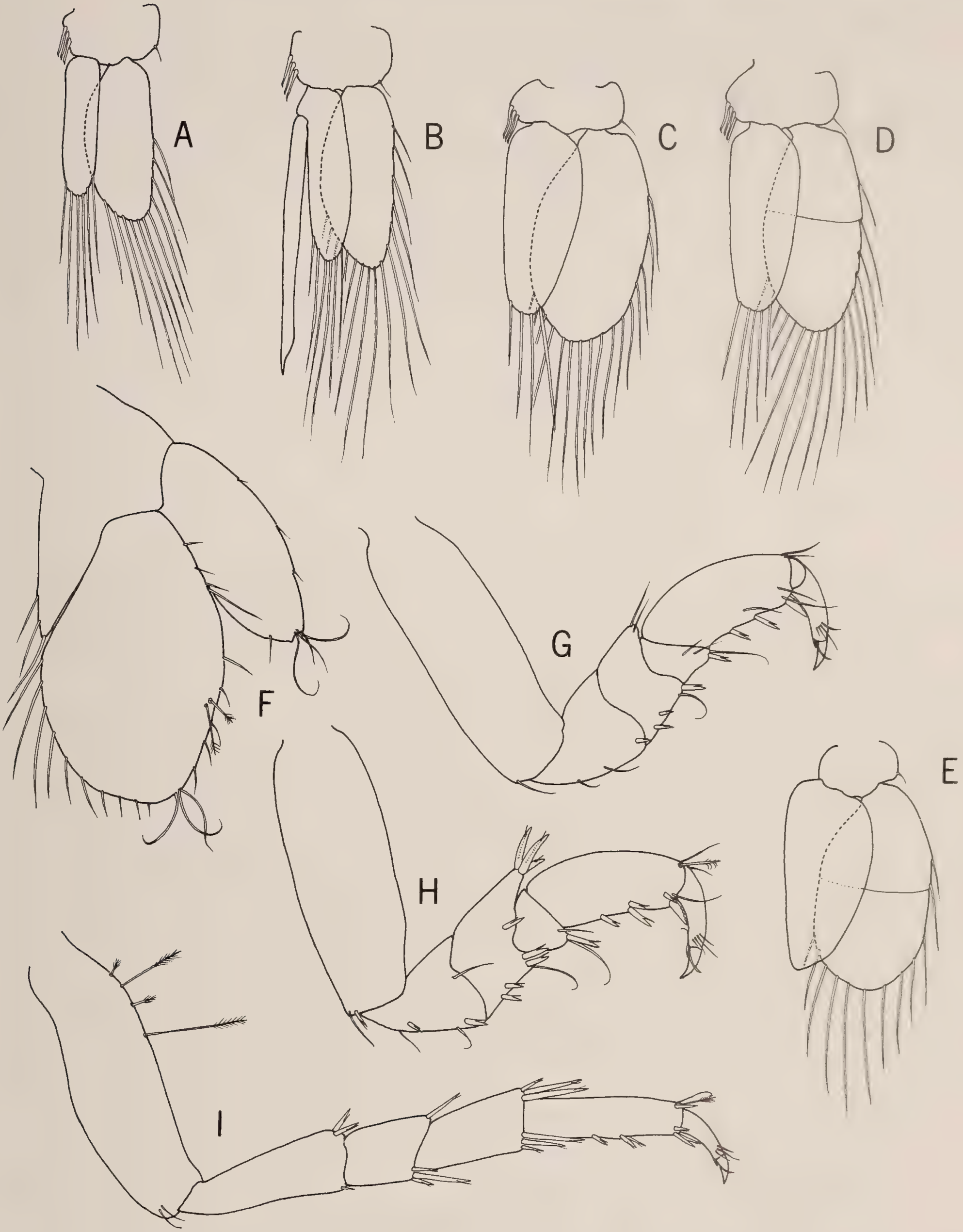

Fig. 28. *Cirolana convexissima* sp. nov. A. Pleopod 1. B. Pleopod 2 male. C. Pleopod 3. D. Pleopod 4. E. Pleopod 5. F. Uropod. G. Pereopod 1. H. Pereopod 2. I. Pereopod 7.

Etymology

The specific name, from the Latin meaning very convex or arched, refers to the strongly convex dorsum of the animal.

Family **Sphaeromatidae**

Subfamily Sphaeromatinae

Paracilicaea Stebbing, 1910

Paracilicaea cordylina sp. nov.

Figs 29–30

Material

Zululand. Holotype SAM–A17838, SM 15, 27°31′S 32°45′E, 280–454 m, 1 ♂, TL 14,5 mm. (Fragment consisting of left uropod and part of pleotelson taken from same station.)

Description

Male

Body dorsally strongly arched, parallel-sided. Integument indurate, anteriorly shallowly pitted, becoming finely granulate posteriorly. Head anteriorly convex, with strongly pigmented lateral eyes; frontal lamina distally triangular, proximally having two rounded divergent lobes. Pereonite 1 longer than following segments, with broad ventrolateral extension, anteriorly with narrowly rounded lobe, posteriorly acute. Pereonites 2–7 subequal in length and width; coxae 2 and 3 triangular, apically subacute; coxae 4–7 rounded, becoming shorter and broader posteriorly. Pereonites 6 and 7 each with two pairs low granular tubercles close to posterior margin; pereonite 7 posterior margin faintly bilobed. Pleonites 1–4 fused medially, pleonite 1 visible only as arc-shaped segment posterodorsal to coxa 7; pleonite 3 with single granular tubercle on posterior margin; pleonite 4 with two strong conical submedian tubercles near posterior margin, laterally with bilobed granular tubercle just mesial to rounded lateral margin. Pleotelson strongly convex, with proximal half raised into two low granular tubercles and two stronger conical tubercles at about midlength; posterior margin with shallow terminal notch flanked by low rounded tubercle.

Antennule with basal article longest and widest, distal three-fourths flexed at right angle to basal part, with faint tubercle on anterior margin; article 2 slightly more than one-third length of slender cylindrical article 3; flagellum of eighteen articles. Antenna, basal article short, rounded; articles 2 and 3 subequal in length, shorter than article 4; articles 4 and 5 subequal in length; flagellum of seventeen articles. Mandible, incisor semicircular along blunt cutting edge, strongly sclerotized; lacinia distally broadened, of three blunt cusps; five strong spines in spine row; molar stout, truncate, fringed with dense band of short spines; palp with article 1 subequal in length to article 2, latter bearing row of twelve spines distally; article 3 curved, armed with row of sixteen short and

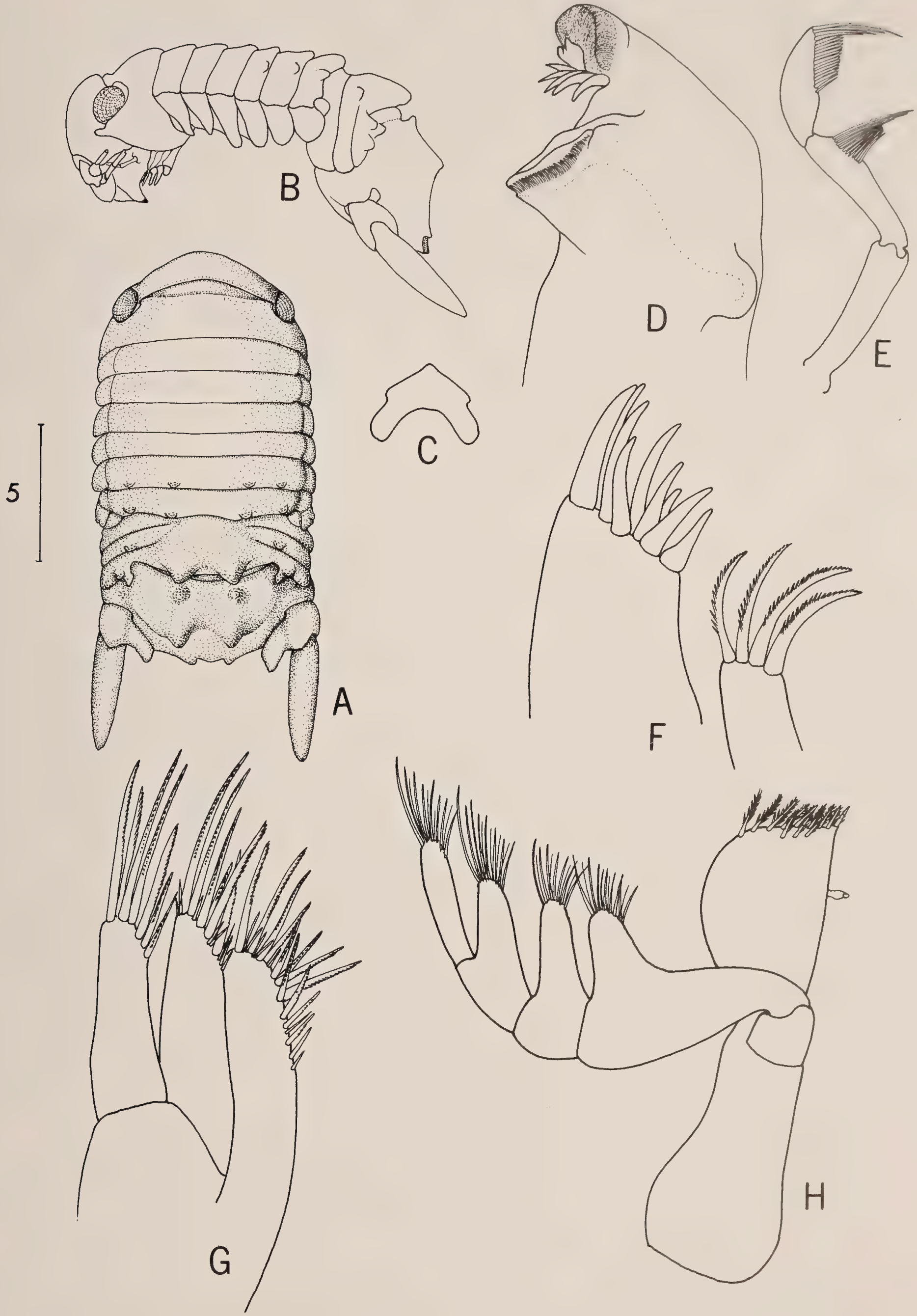

Fig. 29. *Paracilicaea cordylina* sp. nov. A. Holotype, dorsal view. B. Holotype, lateral view. C. Frontal lamina. D. Mandible. E. Mandibular palp. F. Maxilla 1. G. Maxilla 2. H. Maxilliped. Scale = 5 mm.

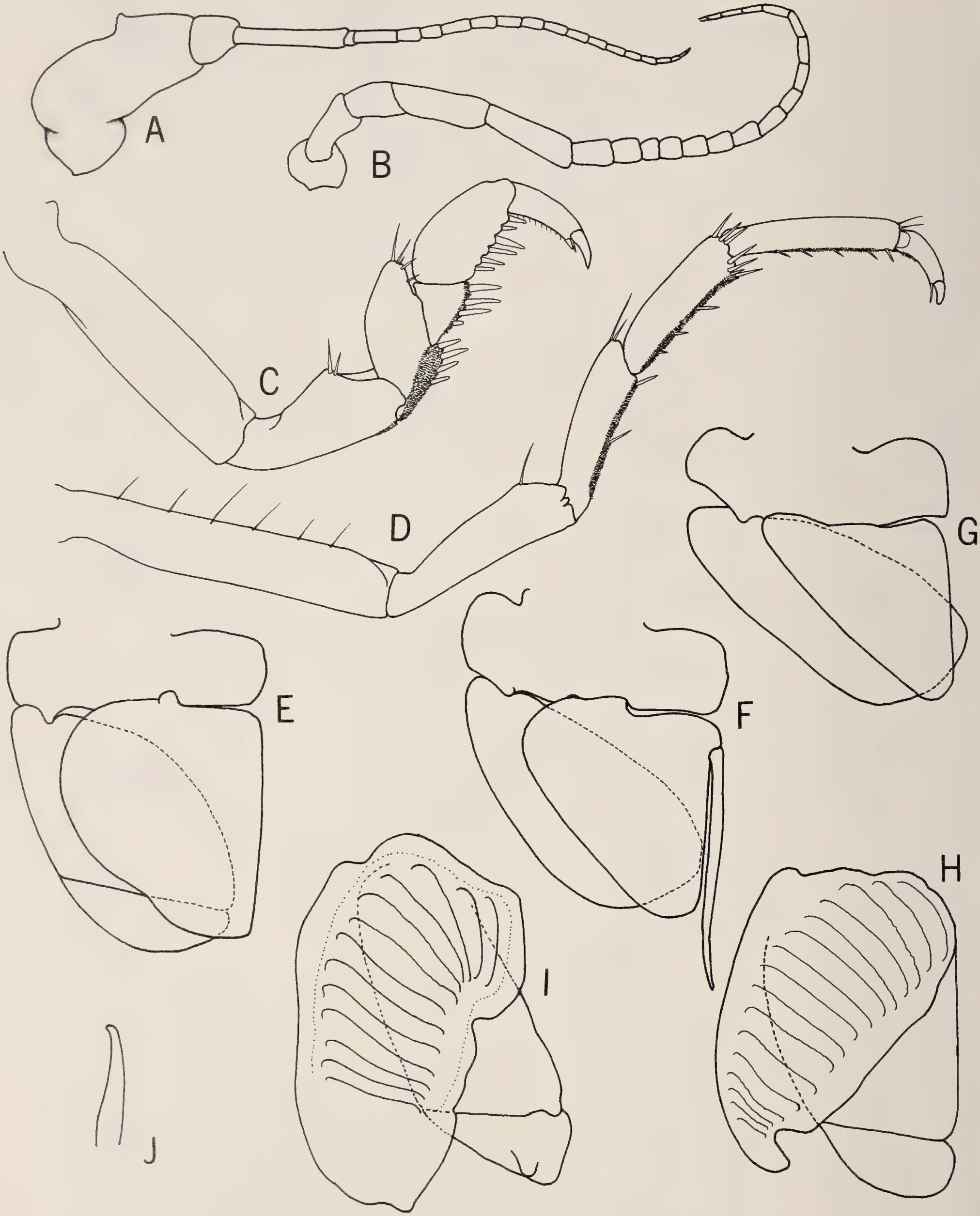

Fig. 30. *Paracilicaea cordylina* sp. nov. A. Antennule. B. Antenna. C. Pereopod 1. D. Pereopod 7. E. Pleopod 3. F. Pleopod 2. G. Pleopod 1. H. Pleopod 4. I. Pleopod 5. J. Penial lobe.

four elongate spines. Maxilla 1, inner ramus bearing four strong serrate distal spines; outer ramus with nine stout simple spines. Maxilla 2, inner ramus with about ten elongate serrate spines plus several shorter simple spines mediodistally; inner and outer lobes of outer ramus with six or seven serrate spines each. Maxilliped, endite with single retinaculum on medial margin, outer margin convex, twelve fringed spines on distal margin; palp articles 2–4 with numerous spines on tips of lobes. Pereopod 1, unguis about half length of rest of dactylus; propodus with six spines on posterior margin; carpus triangular, with four spines and fine spinule patch on posterior margin; merus with rounded distodorsal lobe bearing few slender spines, four strong spines and broad spinule patch on posterior margin. Pereopod 7, propodus narrow-cylindrical, with five slender spines and narrow band of spinules on posterior margin; carpus narrow, cylindrical, with several spines distally, four spines and broad spinule band on posterior margin; merus with two spines and broad spinule patch on posterior margin. Penial processes on sternum of pereonite 7 slender elongate, distally faintly hooked. Pleopod 1, endopod triangular, exopod elongate-oval; pleopod 2 with slender copulatory stylet articulating basally on triangular endopod, reaching well beyond apex of rami, exopod elongate-oval; pleopod 3, endopod with outer margin becoming strongly convex; exopod elongate-oval with narrow distal article; pleopods 4 and 5, exopod biarticulate, thin membranous; endopod pleated. Uropod with short distally rounded inner ramus fused with basis, outer ramus elongate-cylindrical, tapering distally to narrowly rounded apex.

Remarks

The present species of *Paracilicaea* differs from the three intertidal species described from Mozambique in several features, but is most easily distinguished by pleonal structure.

Paracilicaea teretron Barnard, 1955, has only two submedian dorsal tubercles on the pleotelson, while the three lobes of the pleotelsonic apex, and the uropodal endopod, are more elongate than in *P. cordylina*. The former species also lacks tubercles on the posterior pereonites.

Paracilicaea mossambicus Barnard, 1914, with trilobed apices of the telsonic lobes and uropodal rami, is quite distinctive.

Paracilicaea clavus Barnard, 1955, has two very strong, rather than four smaller, submedian pleotelsonic tubercles and more elongate lobes of the pleotelsonic apex.

Paracilicaea hanseni Stebbing, 1910, from Zanzibar, possesses more pereonal tubercles, a very strong submedian pair of pleonal tubercles, curved uropodal exopods, and more elongate pleotelsonic apical lobes.

Of the four species of *Paracilicaea* recorded by Hale (1929) from South Australia, *P. hamata* possesses a distally hooked uropodal exopod; *P. septemdentata* has a strongly dentate uropodal exopod; *P. pubescens* has a granulate and densely pubescent body; and *P. gigas* is also pubescent, with a narrow notched pleotelsonic apex.

Etymology

The specific name, from the Greek *kordylinos*, meaning club-like, refers to the shape of the uropodal ramus.

INFRAORDER ASELLOTA

Family **Stenetriidae**

Stenetrium Haswell, 1881

Stenetrium perestrelloi sp. nov.

Figs 31–32

Material

East London area. Holotype SAM–A17839, SM 163/4, 33°04′S 28°06′E, 90 m, 1 ♂, TL 6,5 mm. Paratypes SAM–A17840, SM 163/4, 90 m, 1 ovig. ♀, TL 5,1 mm, 1 ♀, TL 5,9 mm, 15 juvs. USNM 189077, SM 163/4, 90 m, 1 ♂, TL 6,0 mm, 3 juvs.

Description

Male

Body three and one-half times longer than wide, widest at pereonite 7. Integument with diffuse brown pigmentation, strongest around eye, localized lateral dark patches on pereonites, diffuse lateral band on pleon. Anterior half of body with scattered elongate setae. Head with lateral margins entire; anterolateral angle acute; rostrum roughly pentagonal, widest at base, apically narrowly rounded, distal margin with hyaline teeth (easily broken off). Eyes reniform, strongly pigmented. Pleon slightly wider than long; lateral margins entire; posterior margin between uropod bases evenly rounded.

Antennule with flagellum of thirteen articles, eleven distal articles each bearing single aesthetasc. Basal antennal article with tooth-like lobe at outer distal angle. Mandibular palp, article 2 bearing two strong serrate spines and distal row of ten short spines; distal article widest at midlength, with distal narrowed part, both regions bearing spines. Maxilla 1, inner ramus with one narrow and two stout serrate spines; outer ramus with ten toothed spines. Maxilla 2, inner ramus with thirteen to fifteen fringed spines on mediodistal margin; both lobes of outer ramus bearing four elongate fringed spines. Maxilliped with six retinaculae and distal row of fringed spines on medial margin; article 3 with broadly rounded mediodistal lobe. Pereopod 1 dactylus overlapping propodal palm by about one-fourth of its length; propodus broad, palm armed with strong triangular outer and large inner tooth, with three small teeth between them; small triangular tooth close to dactylar articulation on medial surface; dactylus, anterior and posterior margins of propodus, and posterior margins of carpus and merus with dense setae; merus and ischium with triangular lobe on anterodistal angle. Posterior pereopods with strongly biunguiculate dactyli, with narrower proximal spine; propodi and carpi elongate-rectangular, with sensory spines on posterior

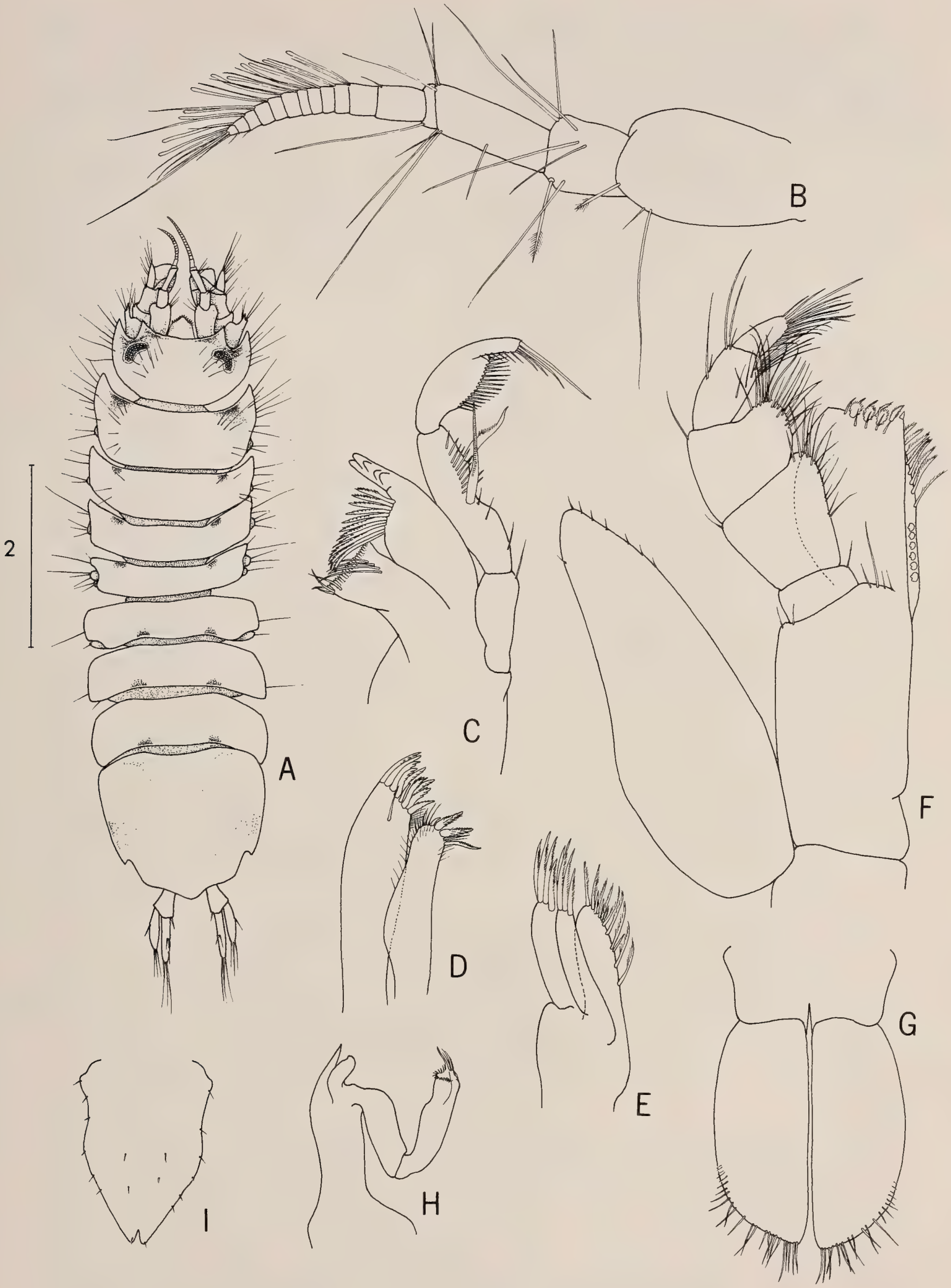

Fig. 31. *Stenetrium perestrelloi* sp. nov. A. Male, dorsal view. B. Antennule. C. Mandible. D. Maxilla 1. E. Maxilla 2. F. Maxilliped. G. Pleopod 1 male. H. Pleopod 2 male. I. Operculum, female. Scale 2 mm.

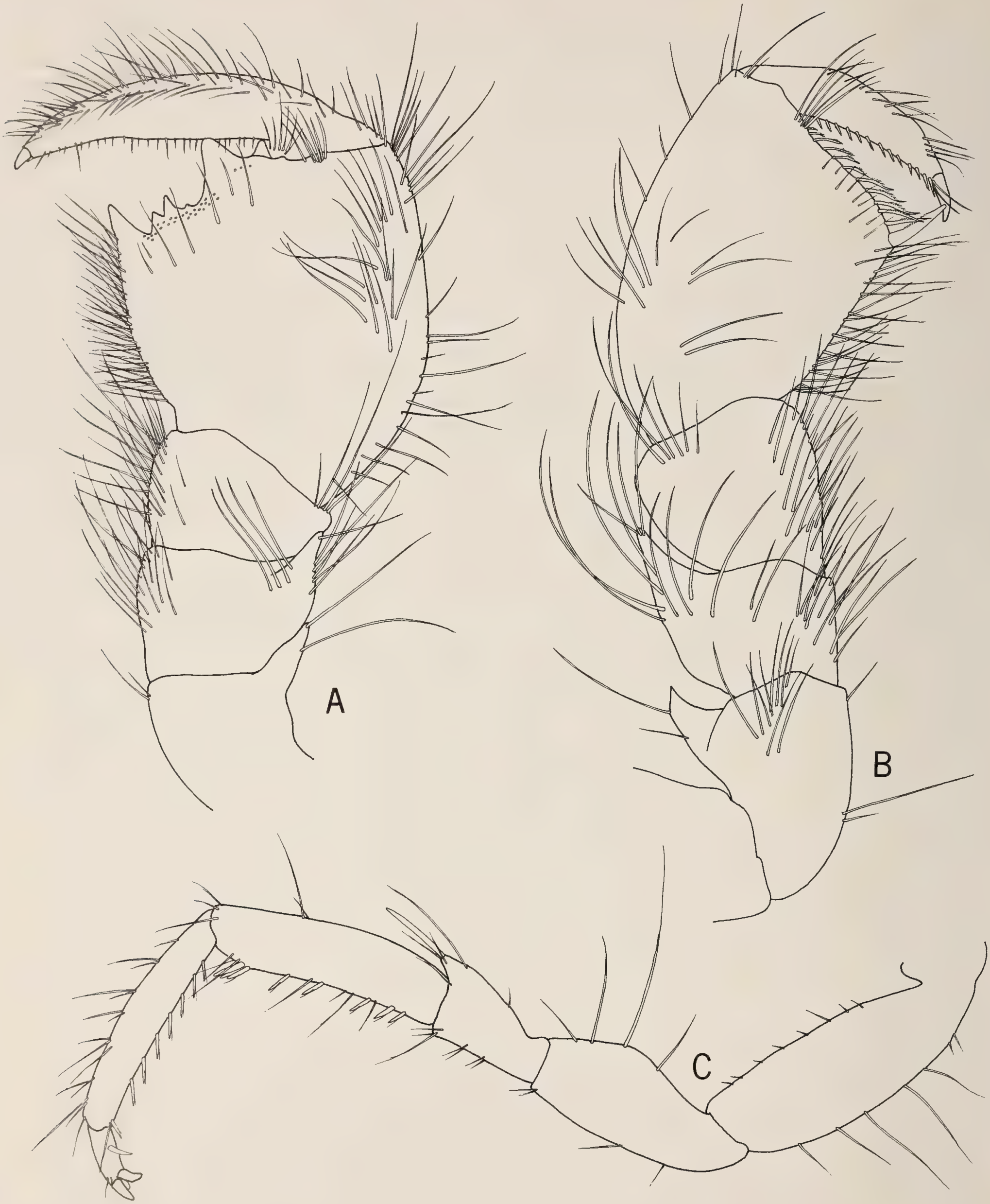

Fig. 32. *Stenetrium perestrelloi* sp. nov. A. Pereopod 1, male. B. Pereopod 1, female. C. Pereopod 7.

margins; meri with strong elongate spine on anterodistal angle. Pleopod 1, rami with outer distal margins evenly rounded, bearing row of short setae, inner apices subacute. Uropods with inner ramus slightly longer and narrower than outer, both rami tipped with elongate setae.

Female

Pereopod 1, dactylus with row of short serrate spines on cutting edge; propodus with strong posterodistal serrate spine, palm with eleven slender fringed spines. Operculum with short apical notch.

Remarks

Of the eight southern African species of *Stenetrium* having well-pigmented reniform eyes, *S. perestrelloi* most closely resembles *S. esquartum* Schultz, 1982*a*, known from False Bay to the East London area. Schultz's species has a very similar rostrum and palmar armature on pereopod 1 ♂, but a more elongate propodus, serrate lateral margins of the pleon, pleopod 1 ♂ is distally truncate-rounded, the antennular flagellum has more articles, while the inner lobe of maxillipedal palp article 3 is not as broadly rounded.

Stenetrium crassimanus Barnard, 1914, is similar to the present species in the broadly setose pereopod 1 of the male, but has three equally strong palmar teeth (see Kensley 1978*e*, fig. 65F), and a triangular rostrum, unlike *S. perestrelloi* which has large and small palmar teeth and a roughly pentagonal rostrum.

Etymology

The species is named after Manoel de Mesquita Perestrello, a sixteenth-century Portuguese explorer who mapped the east coast of South Africa. (K. H. Barnard previously named four species of *Stenetrium* after Portuguese explorers.)

Family **Janiridae**

Ianisera Kensley, 1976

Ianisera expansa sp. nov.

Figs 33–34

Material

Holotype SAM–A17841, SM 129, 30°53′S 30°31′E, 850 m, 1 ♂, TL 3,2 mm; allotype, 1 ovig. ♀, TL 3,1 mm. Paratypes SAM–A17842, SM 123, 30°33′S 30°48′E, 690 m, 2 ♂, 2 ♀. Paratypes SAM–A17843, SM 103, 28°31′S 32°34′E, 680 m, 4 ♀. Paratypes SAM–A17844, SM 86, 27°59′S 32°40′E, 550 m, 1 ovig. ♀, 2 ♀. Paratypes SAM–A17845, SM 129, 850 m, 3 ♂, 3 ovig. ♀, 3 ♀. Paratypes SAM–A17846, SM 185, 33°39′S 27°11′E, 90 m, 1 ♀, 3 juvs. Paratypes USNM 189079, SM 226, 32°28′S 28°58′E, 710–775 m, 3 ♂, 1 ovig. ♀, 2 ♀.

Description

Male

Body strongly dorsoventrally flattened, parallel-sided, three times longer than wide, widest at pereonite 6. Head with poorly pigmented dorsolateral eyespots, lacking ommatidia; frontal margin medially very gently convex; lateral margins convex, finely serrate. Pereonites with lateral margins faintly serrate, serrations becoming obsolete posteriorly in adult specimens; pereonites 2 and 3 laterally bilobed. Pleon of single segment, wider than long, lateral margins finely serrate, posterior margin evenly rounded between uropodal bases. Antennule reaching to base of antennal peduncle article 5, with broad flattened basal article, five distal articles; single aesthetasc on terminal and subterminal article. Antenna (broken in most specimens) with three proximal peduncle articles together shorter than article 4; article 2 with short accessory scale; article 5 one and two-thirds length of article 4; flagellum longer than peduncle, of about thirty articles. Mandibular palp with basal article longer than article 2, latter with three strong serrate spines in distal half; article 3 strongly curved, with seven proximal simple spines and row of distal spines increasing in length to longest terminal spine; incisor of four indurate cusps; lacinia mobilis stout, bearing four or five serrations; four fringed spines in spine row; molar stout, with distally truncate grinding surface. Maxilla 1, inner ramus with two fringed setae and several finer setules; outer ramus with eight serrate spines. Maxilla 2, inner ramus one and one-half times wider than lobes of outer ramus, bearing several simple and fringed setae on mediodistal margin; lobes of outer ramus each bearing three elongate fringed setae. Maxilliped with articles 2 and 3 of palp expanded; endite with several fringed and simple spines distally, short single spine at mediodistal angle, two coupling hooks on medial margin. Pereopods all biunguiculate; pereopod 1 shorter than following legs; few short sensory spines on posterior margins of propodi and carpi. Pleopod 1 basally broad, rami fused for three-fourths of length, distally with semicircular marginally setose median area, and triangular spinose lateral lobe. Pleopod 2, inner ramus distally greatly produced into fine whip-like structure; outer ramus with setose shoulder in distal half of lateral margin. Pleopod 3, inner ramus with three stout plumose setae; outer ramus of two articles, both setose on outer margins. Uropod with stout basis, inner ramus slightly wider and almost one-fourth longer than outer, both rami tipped with fine setae.

Ovigerous female

Overall proportions and appendages as in male. Operculum subcircular, with marginal fringe of setae on distal third.

Remarks

Given the uncertain status of many of the nominal janirid genera, placing of the present species must be tentative. The general body form and the appendages suggest an affinity with the *Janira–Neojaera–Ianiropsis–Janilirata* group

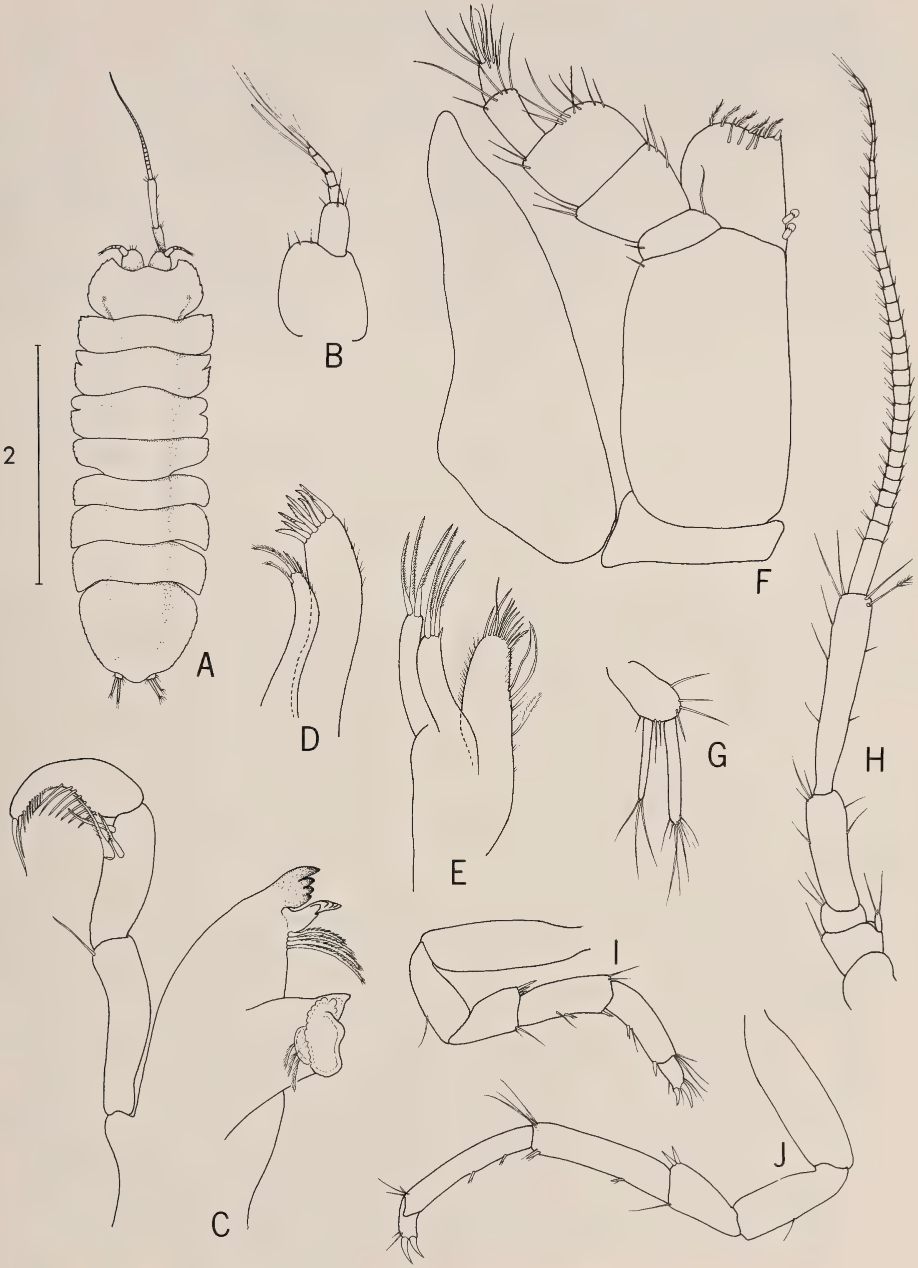

Fig. 33. *Ianisera expansa* sp. nov. A. Male, dorsal view. B. Antennule. C. Mandible. D. Maxilla 1. E. Maxilla 2. F. Maxilliped. G. Uropod. H. Antenna. I. Pereopod 1. J. Pereopod 7. Scale = 2 mm.

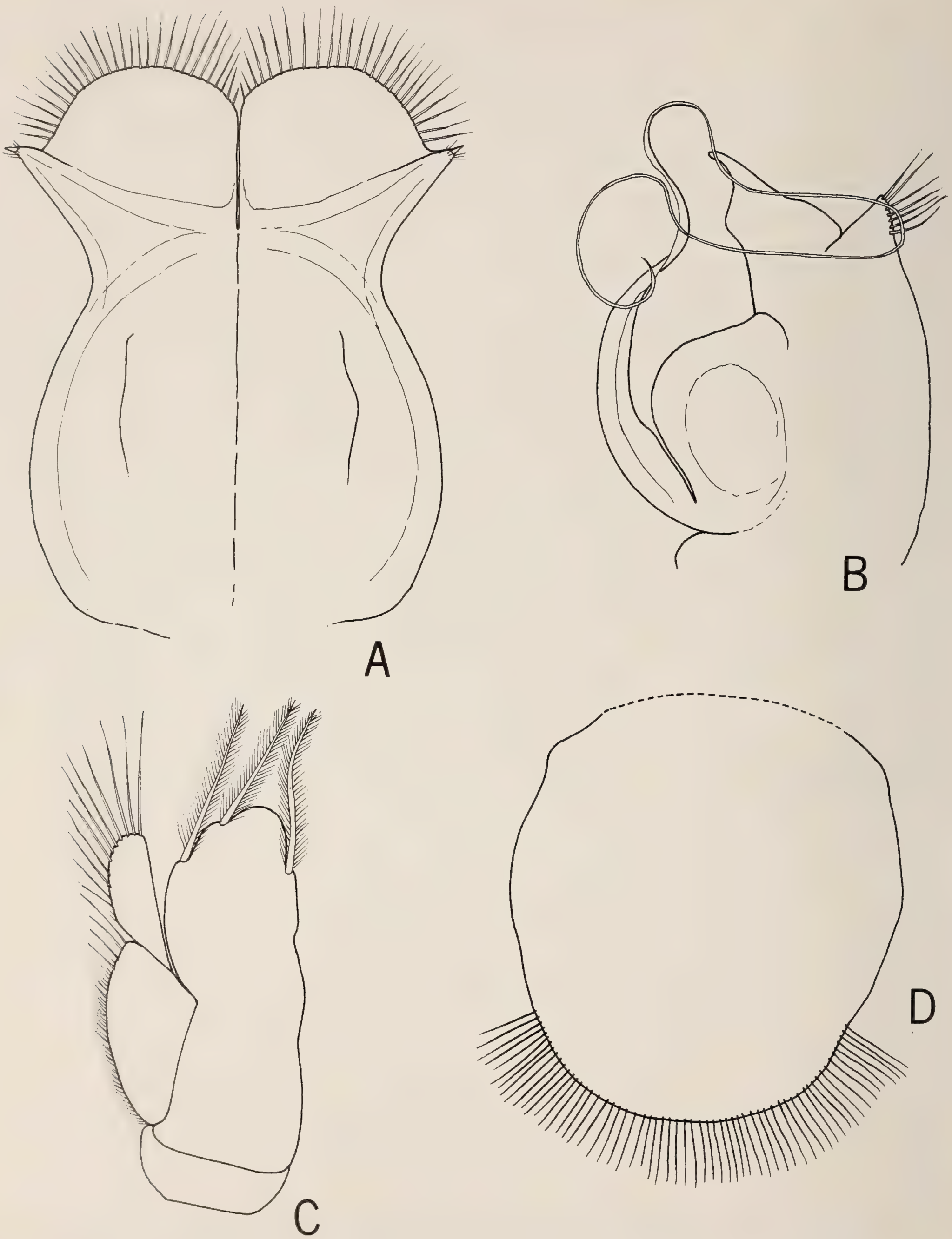

Fig. 34. *Ianisera expansa* sp. nov. A. Pleopod 1, male. B. Pleopod 2 male. C. Pleopod 3 male. D. Operculum, female.

of genera. The biunguiculate pereopods, minute eyes, very short uropods, elongate antennae, lack of rostrum, and the whip-like extension of the inner ramus of pleopod 2 in the male most closely resemble the situation in *Neojaera* (see Menzies 1962*b*: 74). The remarkable distal expansion of pleopod 1 in the male, however, is very similar to *Ianisera trepidus* Kensley, 1976, from Amsterdam Island, southern Indian Ocean, and, mainly for this reason, the new species is placed in this genus. *Ianisera expansa* differs from *I. trepidus* in having a less setose integument, more slender uropodal rami, a more elongate antenna, finely serrulate lateral margins of the head and pereonites, and shorter spiniform lateral lobes of the male pleopod 1. It is possible that *Ianisera* will be found to be synonymous with *Neojaera*, when the much-needed revision of the family is produced.

Etymology

The specific name refers to the expanded distal lobes of the male pleopod 1.

Natalianira gen. nov.

Diagnosis

Head not fused with pereonite 1; eyes lacking. Antennule longer and broader than antenna. Mandibular palp three-articulate; molar spiciform, slender; spine row reduced. Maxillipedal palp five-articulate. Pereopod 1 pseudochelate. Pereopods 2–7 uni-unguiculate. Pleon consisting of single segment. Uropod uniramous, of one (?two) articles.

Type species

Natalianira spinosa sp. nov., by original designation.

Remarks

Of the approximately 40 genera of the Janiridae, only *Janirella* and *Katianira* possess uniramous uropods. The former, however, unlike *Natalianira*, always has a distinctly biarticulate uropod, a prehensile subchelate pereopod 1, antennae (bearing an accessory scale) longer than the antennules, and a stout distally truncate molar and well-developed spine row on the mandible.

Katianira Hansen, 1916, resembles *Natalianira* in the slender tapering mandibular molar, reduced spine row, and in the 'chelate' pereopod 1. Several differences, however, are apparent. The maxillipedal palp is four-articulate, five in *Natalianira*; the two pairs of antennae are subequal in *Katianira*, while the spine row of the latter consists of two elongate spines. In *Natalianira* the spine row consists of two very short spines in the left, and two flattened structures in the right.

The highly modified mandible and uropod of *Natalianira*, which differ from those of most genera of the Janiridae, suggest that this is a far more apomorphic form than most members of the family. The highly spinose nature of the body margins and appendage margins, and the pseudochelate pereopod 1 may be an adaptation for life in a rubble or organic detritus-rich habitat. In all specimens, the body outline was obscured by debris entangled in the marginal spines.

Etymology

The generic name is a combination of 'Natal', along the continental shelf of which province the animals were collected, and '*Janira*', the type genus of the family. Gender: feminine.

Natalianira spinosa sp. nov.

Figs 35–36

Material

Zululand to southern Natal area. Holotype SAM–A17865, SM 123, 30°33′S 30°48′E, 690 m, 1 ♂, TL 2,5 mm. Paratypes SAM–A17866, SM 129, 30°53′S 30°31′E, 850 m, 1 ovig. ♀, TL 3,0 mm, 1 ♂, TL 2,5 mm. Paratype USNM 189082, SM 86, 27°59′S 32°40′E, 550 m, 1 ♂, TL 2,5 mm. Paratype USNM 189083, SM 103, 28°31′ 32°34′E, 680 m, 1 ♂, TL 2,1 mm.

Description

Male

Body elongate-oval. Head slightly more than three times wider than long; frontal margin straight, armed with row of spines; eyes lacking, but unpigmented rounded lobe present lateral to antennular base; broader spinose rounded lobe posterolateral to eye rudiment; dorsum with four spinose tubercles. Pereonite 1 with spinose lateral margin consisting of single lobe; pereonites 2–7 each with bilobed spinose lateral margins; all pereonites bearing one middorsal and two lateral rounded spine-bearing tubercles. Pleon consisting of single segment, with rounded lateral lobe in anterior half, posterior margin between uropodal bases tapering to rounded apex; dorsally rounded with large middorsal and smaller lateral spinose tubercles.

Antennule with broad flattened basal article bearing two spines on medial and eight spines on outer margins; flagellum of eight articles, second article four times longer than first, articles 4–7 each with single aesthetasc, terminal article with three aesthetascs. Antenna considerably shorter and narrower than antennule, of five peduncle articles and single flagellar article. Mandible with three-articulate palp, basal article about one-fifth longer than second, distal article shorter than second, with six spines on distal margin; incisor of two or three narrow cusps; bicuspid lacinia mobilis on one side, with two very small spines in spine row, three flattened spines on other side; molar spiciform, with one small distal tooth on one side; bluntly triangular keel-like structure distal to palp insertion. Maxilla 1, inner ramus with three elongate serrate spines and one very short simple spine distally; outer ramus with thirteen simple and serrate spines. Maxilla 2, inner ramus

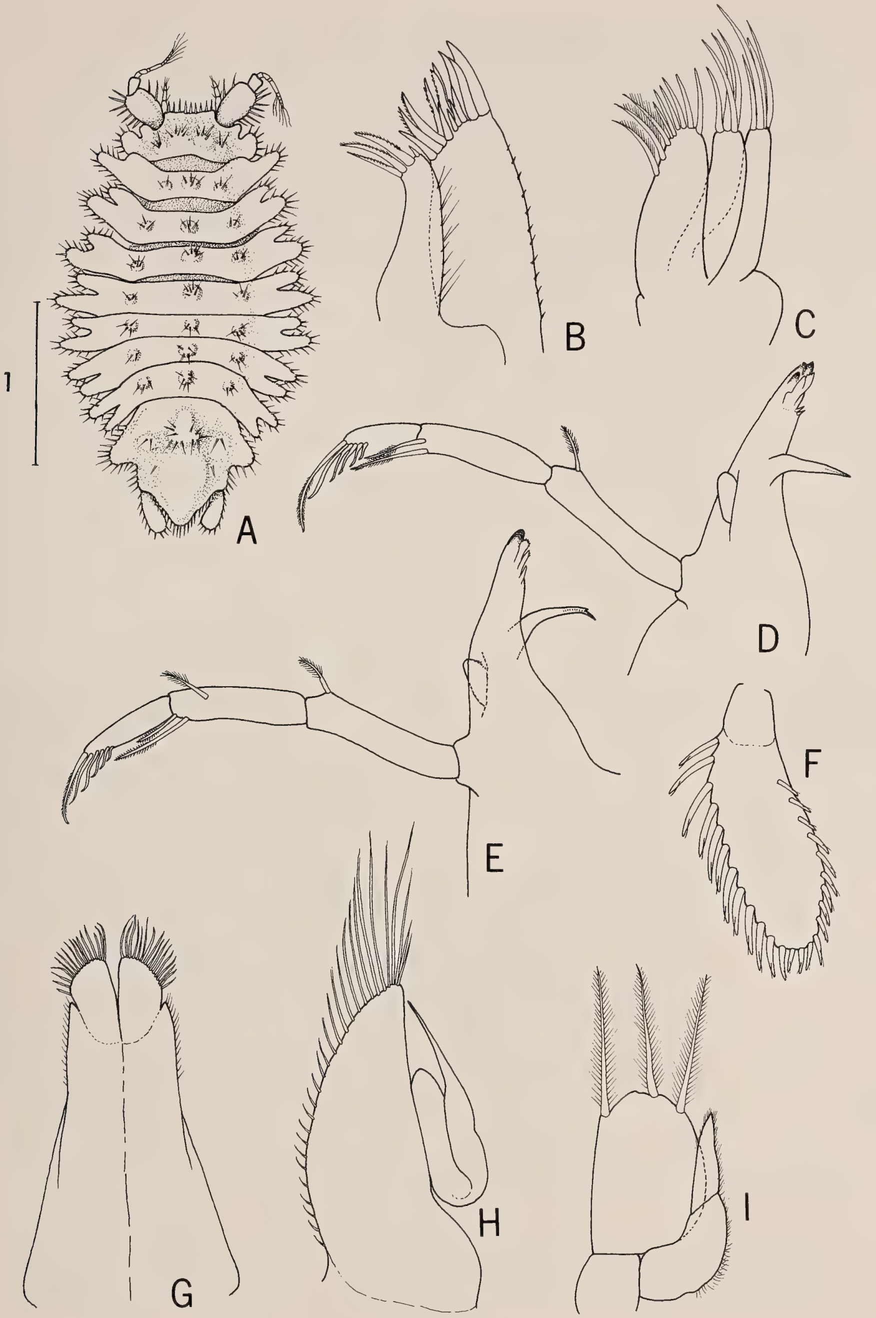

Fig. 35. *Natalianira spinosa* sp. nov. A. Holotype, dorsal view. B. Maxilla 1. C. Maxilla 2. D. Right mandible. E. Left mandible. F. Uropod. G. Pleopod 1 male. H. Pleopod 2 male. I. Pleopod 3 male. Scale = 1 mm.

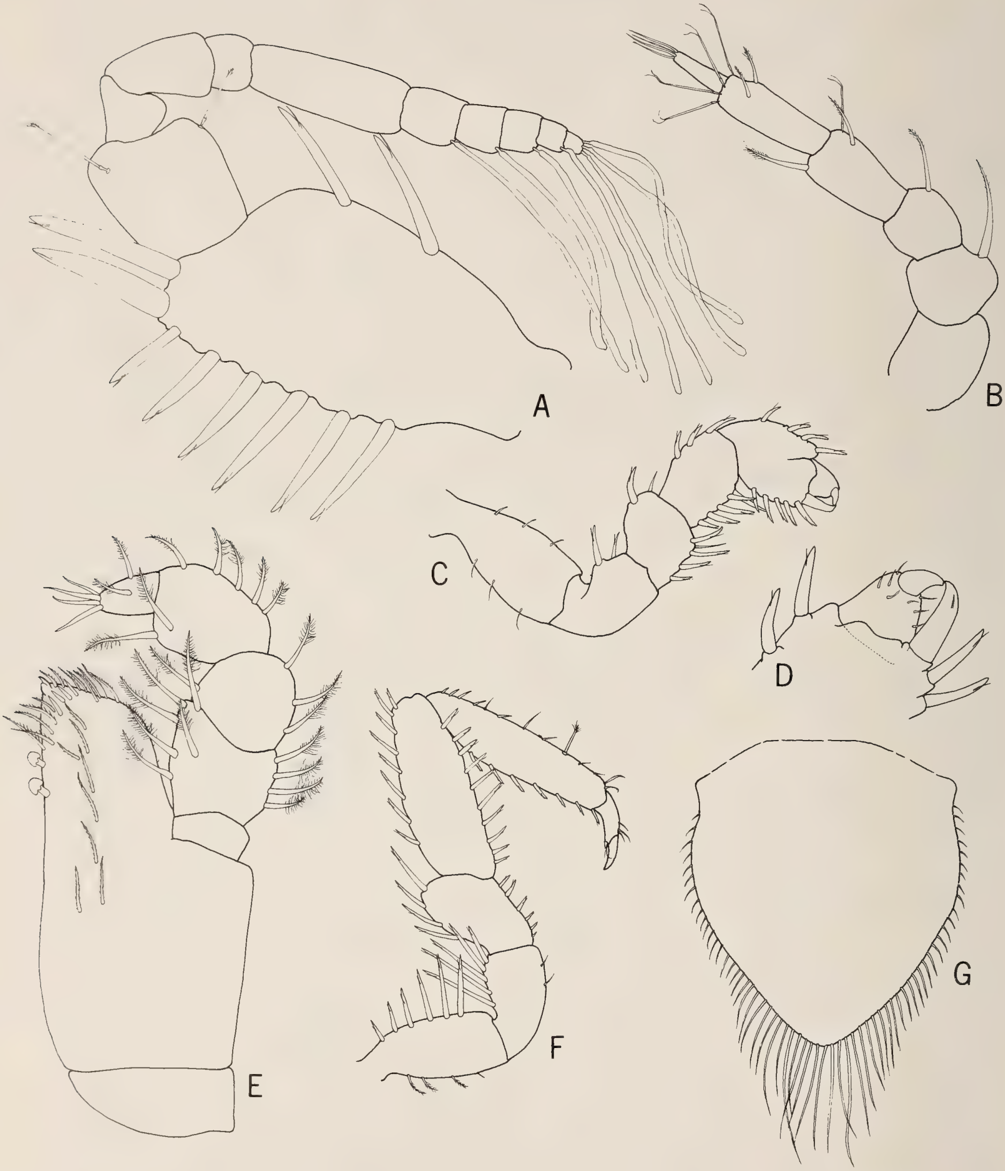

Fig. 36. *Natalianira spinosa* sp. nov. A. Antennule. B. Antenna. C. Pereopod 1. D. Dactylus and propodus, pereopod 1. E. Maxilliped. F. Pereopod 7. G. Operculum, female.

with three elongate fringed spines on mesial margin, six simple spines on distal margin; both lobes of outer ramus each with four elongate spines. Maxillipedal endite with two coupling hooks on mesial margin, short irregular spine at mediodistal angle; several fringed setae on mesial and distal margin, and outer surface; palp of five articles, four distal articles bearing stout fringed spines on both margins, article 4 as broad as two preceding articles; terminal article tipped with four simple setae. Pereopod 1 shorter than following legs; dactylus short, broad, hooked, unguis meeting stout spine at posterodistal angle of propodus; propodus, carpus, merus, and ischium bearing stout sensory spines. Pereopods 2–7 similar, anterior and posterior margins of propodi, carpi, meri, ischia, and anterior margin of basis bearing row of stout sensory spines. Pleopod 1, rami fused for three-fourths length, lobes distally rounded-truncate, margins oblique, bearing several simple setae. Pleopod 2 outer ramus bearing marginal plumose setae, becoming distally longer. Pleopod 3, endopod with three elongate distal plumose setae; exopod narrow, tapering distally, uropod elongate-oval, with feeble indication of line of fusion between basal and distal article; latter bearing twenty-five sensory spines.

Female

Body only slightly wider than in male. Brood-pouch formed by three pairs of oostegites on pereonites 2–4. Pleonal operculum slightly longer than wide, tapering gently in distal half to broadly rounded apex, margin bearing plumose setae, latter becoming distally longer.

Etymology

The specific name refers to the very spinose margins of the head, pereon, pleon, and several of the appendages.

Spinianirella Menzies, 1962

Spinianirella walfishensis Menzies, 1962

Fig. 37

Spinianirella walfishensis Menzies, 1962*a*: 171, fig. 55. Wolff, 1962: 34, 262, 271, 274, 275.

Material

East London to Durban area. SAM–A17847, SM 129, 850 m, 1 ♂, 1 ovig. ♀, 3 ♀, 1 juv. SAM–A17848, SM 162, 630 m, 1 ♀. SAM–A17849, SM 226, 710–775 m, 1 ♂. SAM–A17850, SM 236, 660–670 m, 1 ♂. SAM–A17851, SM 250, 150–200 m, 1 ♀. USNM 189080, SM 129, 850 m, 1 ♂, 3 ♀.

Previous records

South Atlantic, Walvis Basin, 1 816–2 970 m.

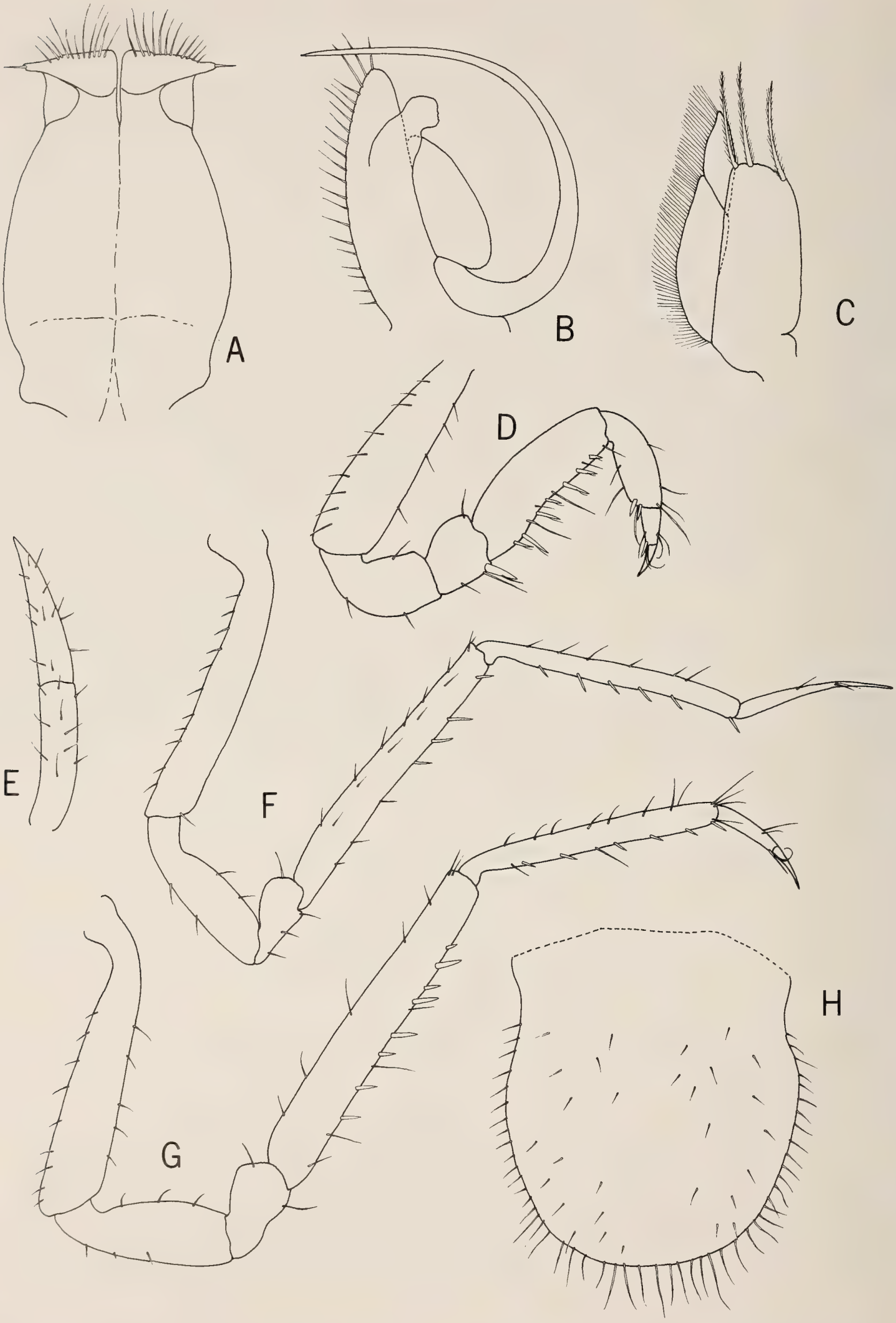

Fig. 37. *Spinianirella walfishensis* Menzies A. Pleopod 1 male. B. Pleopod 2 male. C. Pleopod 3 male. D. Pereopod 1. E. Uropod. F. Pereopod 2. G. Pereopod 7. H. Operculum, female.

Remarks

The present material agrees well with Menzies' description. As this is the first record of the male of this species, figures of the male pleopods 1–3 are provided, as well as additional appendages, to supplement the original description.

Family **Joeropsidae**

Joeropsis Koehler, 1885

Joeropsis integer sp. nov.

Fig. 38

Material

East London area. Holotype SAM–A17852, SM 163, 33°04′S 28°06′E, 90 m, 1 ovig. ♀, TL 3,5 mm. Paratypes SAM–A17853, SM 163, 90 m, 2 ♀, TL 2,8 mm, 3,9 mm.

Description

Ovigerous female

Body almost three times longer than wide. Head with lateral margins entire: frontal plate very gently convex; dorsolateral eyes well developed; broad, roughly pentagonal dorsal pigment patch present. Body widest at pereonite 3. Pleon with lateral margins entire; posterior margin between uropods triangular. Antennule, basal article having rounded distolateral lobe; article 2 about half length and width of article 1; distal article bearing three aesthetascs. Antenna with article 3 having transparent membrane on median margin; flagellum of seven articles. Mandible with three-articulate palp, distal article with eight spines. Maxilla 1, outer ramus with eleven strongly toothed distal spines; inner ramus with three distal setae. Maxilla 2, inner ramus short, with four simple distal spines; two lobes of outer ramus each with three elongate fringed spines and one simple spine. Maxilliped with palp article 2 broadest; article 5 relatively elongate, about twice length of third; endite with few short distal spines; four retinaculae on median margin. Pereopod 1 shorter than following pereopods; dactylus biunguiculate; propodus with four short spines on posterior margin; following pereopods triunguiculate; propodi with seven or eight spines on posterior margins. Operculum broadly oval, longer than wide. Uropodal basis with broadly rounded inner lobe; rami very short, inner longer than outer, both rami bearing elongate setae.

Remarks

All four of the southern African species of *Joeropsis* have either serrate or toothed pleonal margins, unlike the present species, which is entire. *Joeropsis paulensis* (Vanhöffen) from Gough, St. Paul and Amsterdam islands has entire head and pleonal margins but a markedly tapering pleon, and is noticeably

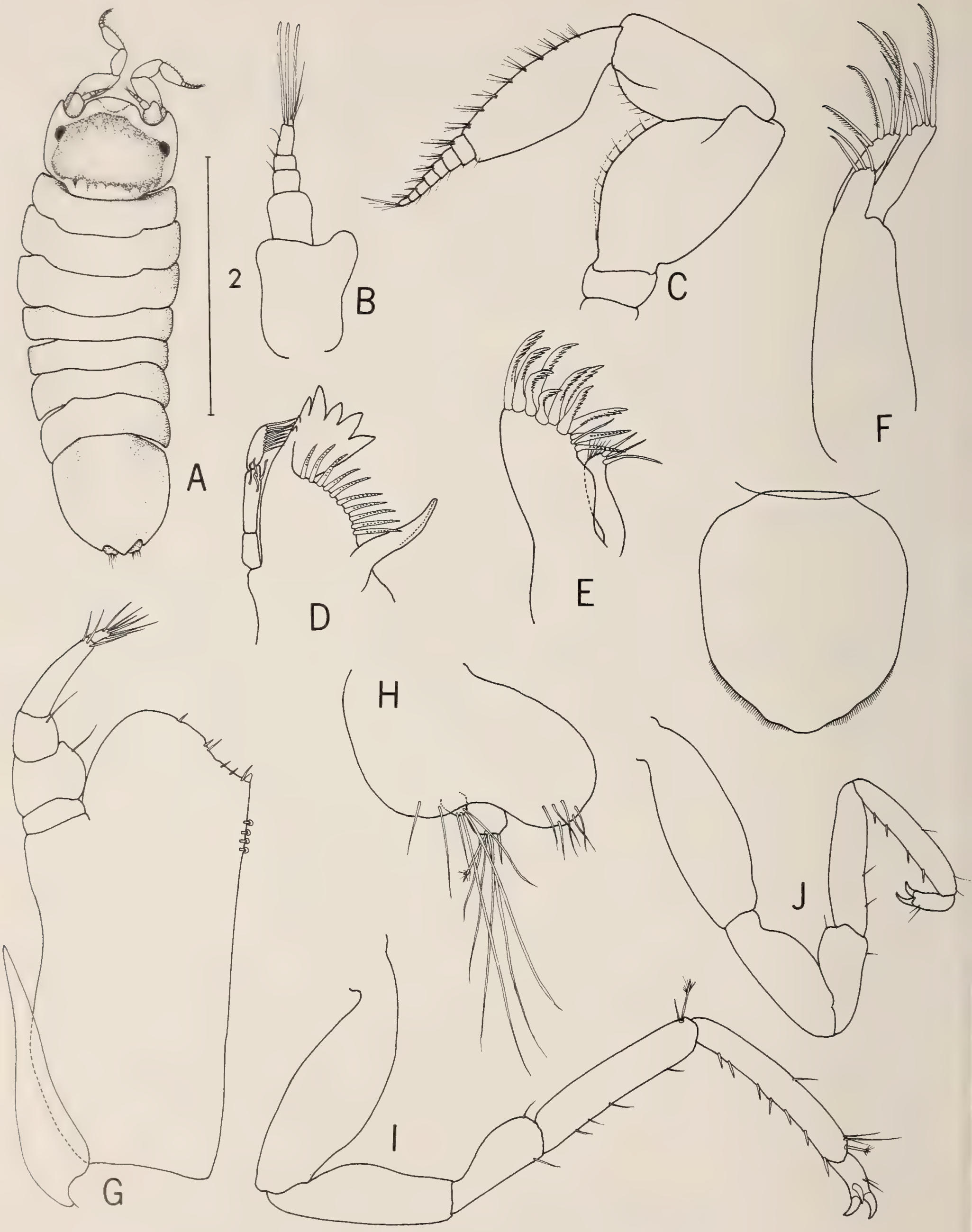

Fig. 38. *Joeropsis integer* sp. nov. A. Holotype, dorsal view. B. Antennule. C. Antenna. D. Mandible. E. Maxilla 1. F. Maxilla 2. G. Maxilliped. H. Uropod. I. Pereopod 7. J. Pereopod 1. Scale = 2 mm.

setose; the frontal plate of the head, while resembling *J. integer*, is more convex, while the maxillipedal palp article 2 is distinctly lobed.

Etymology

The specific name, meaning 'entire', refers to the lateral margins of the head and pleon.

Joeropsis serrulus sp. nov.

Fig. 39

Material

East London area. Holotype SAM–A17854, SM 185, 33°39′S 27°11′E, 90 m, 1 ovig. ♀, TL 2,3 mm. Paratype SAM–A17855, SM 163, 33°04′S 28°06′E, 90 m, 1 ovig. ♀, TL 2,3 mm. Paratype SAM–A17856, SM 164, 33°04′S 28°06′E, 90 m, 1 ♀, TL 2,1 mm.

Description

Ovigerous female

Body about three times longer than wide, broadest at pereonite 3. Head with well-pigmented dorsolateral eyes; lateral margins finely serrate; frontal plate roughly triangular with apex truncate, supported by prominent 'shoulders'; pigment reticulation over entire dorsum. Pereonites with lateral margins finely serrate; pigment reticulation on pereonites 1–6, becoming obsolete posteriorly. Pleon tapering posteriorly, lateral margin with twelve to thirteen teeth; posterior margin triangular between uropods, apex narrowly rounded. Antennule of six articles, basal article broadest and longest, terminal article with single aesthetasc. Antennal flagellum of seven articles. Mandibular palp, basal article subequal to article 2; terminal article with six distal fringed spines; spine row bearing eight slender spines. Maxilla 1, inner ramus with three distal setae, outer ramus with twelve strongly toothed spines. Maxilla 2, inner ramus shorter than lobes of outer ramus, with four distal setae; inner and outer lobes of outer ramus each with four elongate fringed spines. Maxilliped, palp article 2 mesial margin strongly lobed, article 4 elongate, two and one-half times length of article 3; endite with distal margin stepped in mesial half, evenly rounded in outer half; three retinaculae on mesial margin. Pereopod 1 biunguiculate, shorter than following triunguiculate legs; propodi with two or three sensory spines on posterior margin. Operculum slightly longer than wide, distally somewhat narrowly rounded. Uropod reaching beyond pleotelsonic apex, medial lobe of basis with strong distal hook, inner ramus twice length of outer, both rami bearing elongate setae.

Remarks

In possessing finely serrate lateral margins of the head, pereon, and pleon, *Joeropsis serrulus* bears little resemblance to any of the five species described

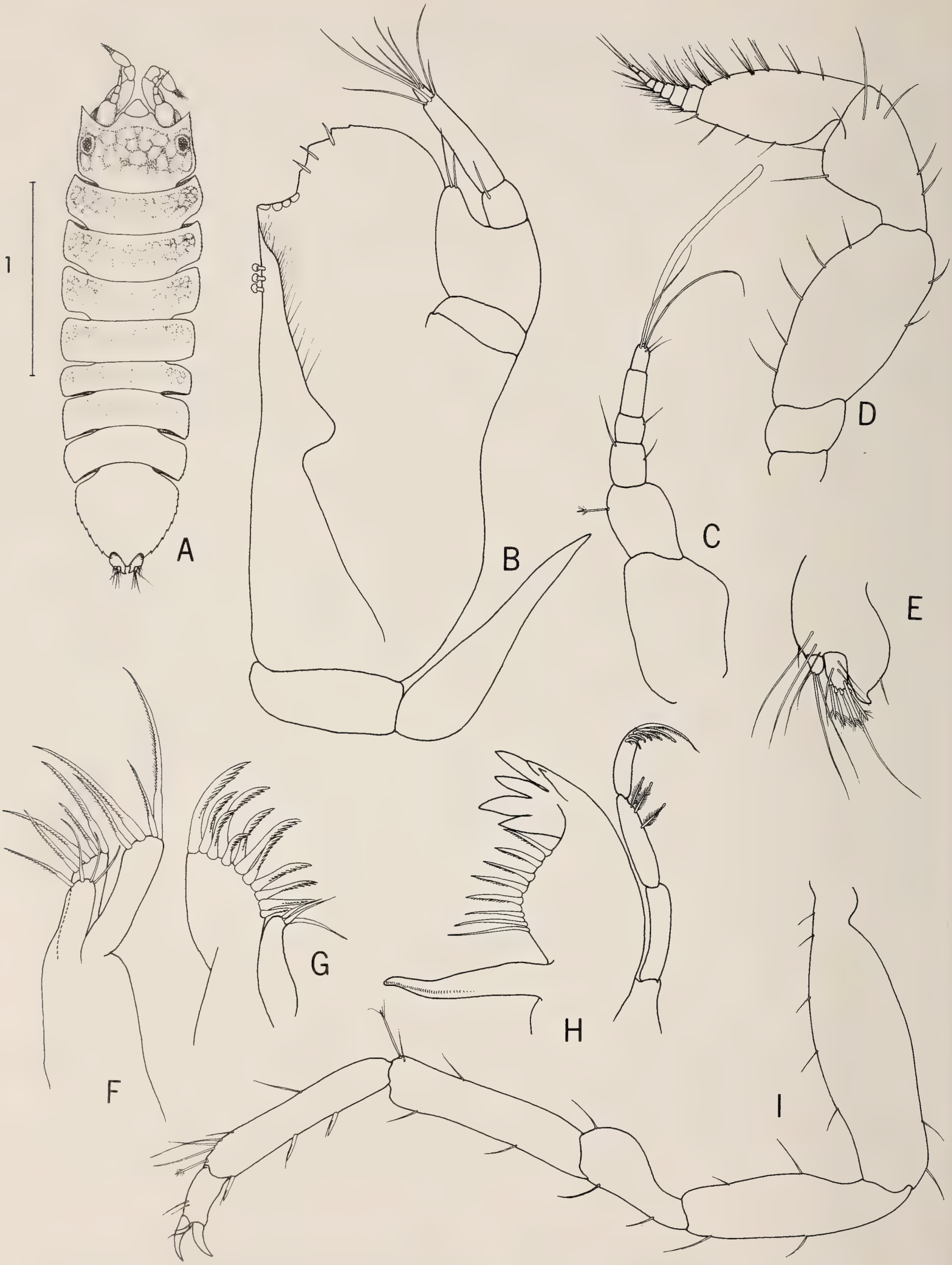

Fig. 39. *Joeropsis serrulus* sp. nov. A. Holotype, dorsal view. B. Maxilliped. C. Antennule. D. Antenna. E. Uropod. F. Maxilla 2. G. Maxilla 1. H. Mandible. I. Pereopod 7. Scale = 1 mm.

from South Africa (see Kensley 1975*b*). *Joeropsis antarctica* (Menzies & Schultz, 1968) possesses coarsely serrate lateral margins of the head and pleon, but apparently smooth pereonite margins.

Etymology

The specific epithet, from the Latin for a little saw, refers to the fine serrations of the head, pereon, and pleon margins of this species.

Family **Pleurogoniidae**

Notoxenoides Menzies, 1962

Notoxenoides acalama sp. nov.

Fig. 40

Material

Holotype SAM–A17857, SM 117, 30°17′S 31°10′E, 820 m, 1 ovig. ♀, TL 2,0 mm.

Description

Ovigerous female

Integument covered dorsally with very fine circular tubercles. Head with anterior margin evenly convex, lacking ocular peduncles and eyes. Pereonites 1–6 each with elongate lateral spinose process and shorter middorsal spine; pereonites 1 and 2 with cluster of three short spines at base of spinose process; coxae visible in dorsal view in pereonites 5–7; pereonite 7 with short middorsal spine, but lacking lateral spinose process. Pleon consisting of two segments; pleonite 1 very short, unarmed; pleotelson subglobose, with lateral margin armed with thirteen or fourteen transparent spines; posterior margin between uropodal bases broadly triangular, apically rounded.

Basal antennular article armed with five dorsolateral spines and two stronger distal spines; article 2 about half length of article 1; four distal articles together subequal to article 2; terminal article bearing single aesthetasc. Mandibular palp three-articulate, terminal article short, curved, bearing single seta; incisor broad, of five cusps; spine row of four elongate serrate spines; molar stout, distally truncate, with irregular marginal serrations. Maxilla 1, inner ramus with one simple, one broadly serrate, and one finely fringed distal seta; outer ramus with eight distal spines. Maxilla 2, inner ramus with eight distal serrate and fringed spines; inner lobe of outer ramus with four elongate setae, outer lobe with three elongate setae. Maxilliped palp with articles 2 and 3 broad, but not as wide as endite; latter with distal margin straight, bearing five fringed setae and two broad sensory fringed spines; two retinaculae on medial margin. Pereopod 1 prehensile, shorter than ambulatory legs, dactylus with strong unguis and shorter accessory spine; propodus with two sensory spines on posterior margin; carpus distally expanded, posterior margin with two elongate stout

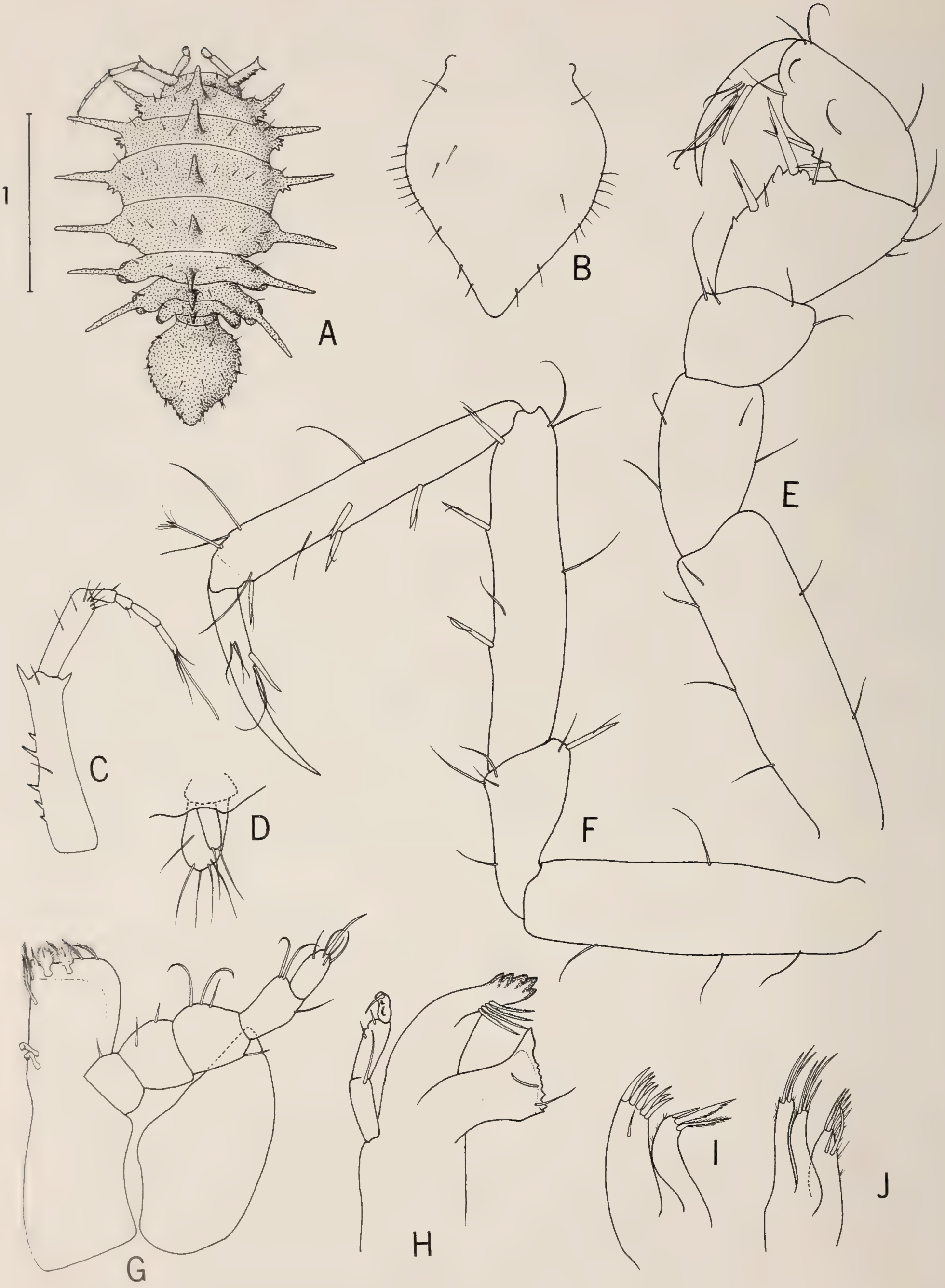

Fig. 40. *Notoxenoides acalama* sp. nov. A. Holotype, dorsal view. B. Operculum, female. C. Antennule. D. Uropod. E. Pereopod 1. F. Pereopod 7. G. Maxilliped. H. Mandible. I. Maxilla 1. J. Maxilla 2. Scale = 1 mm.

sensory spines. Ambulatory pereopods with slender, curved dactylus bearing accessory spine at base of unguis; propodus elongate, with four or five sensory spines on posterior margin; carpus elongate-rectangular, with three sensory spines on posterior margin; merus short, with sensory spine at anterodistal angle. Operculum pyriform, apically narrowly rounded, sparsely setose. Uropodal basis hidden by lateral margin of pleon, outer (dorsal) ramus shorter and one-third width of inner, with two apical setae; inner (ventral) ramus with several distal setae.

Remarks

Three species of *Notoxenoïdes* Menzies, 1962, have been described: *N. abyssi* Menzies, from the west coast of South Africa, 1 816 m; *N. vemae* Menzies, from 4 047 m on the Walvis Ridge, South Atlantic; and *N. dentata* Menzies & George, 1972, from 3 900 m in the Peru–Chile Trench. *Notoxenoides acalama* differs from all three in the lack of ocular peduncles, the lack of lateral spinose processes on pereonite 7, and the lack of a middorsal spine on the first free pleonite.

At 820 m this is the shallowest record for this rare genus (this being the fourth specimen known).

Etymology

The specific name from the Greek, meaning lacking a stalk, refers to the lack of ocular peduncles.

Family **Ischnomesidae**

Haplomesus Richardson, 1908

Haplomesus zuluensis sp. nov.

Fig. 41

Material

Zululand. Holotype SAM–A17858, SM 60, 27°09'S 32°58'E, 800–810 m, 1 ovig. ♀, TL 4,9 mm. Paratype SAM–A17859, SM 60, 800–810 m, 1 ovig. ♀, damaged, pleon missing.

Description

Ovigerous female

Body about five and one-half times longer than broad. Integument brittle, very finely granulate. Head with anterior margin slightly concave medially; dorsally gently convex, sunken into pereonite 1. Latter with small lateral tubercle posterior to strong dorsolaterally directed spine. Pereonites 2 and 3 each with two small submedian tubercles and small lateral tubercle. Pereonite 4 half length of pereonite 5, with small middorsal anterior tubercle, and row of four small submedian tubercles. Pereonite 5 with two submedian rows of small tubercles, becoming obsolete in posterior half of segment. Pereonites 6 and 7 fused with

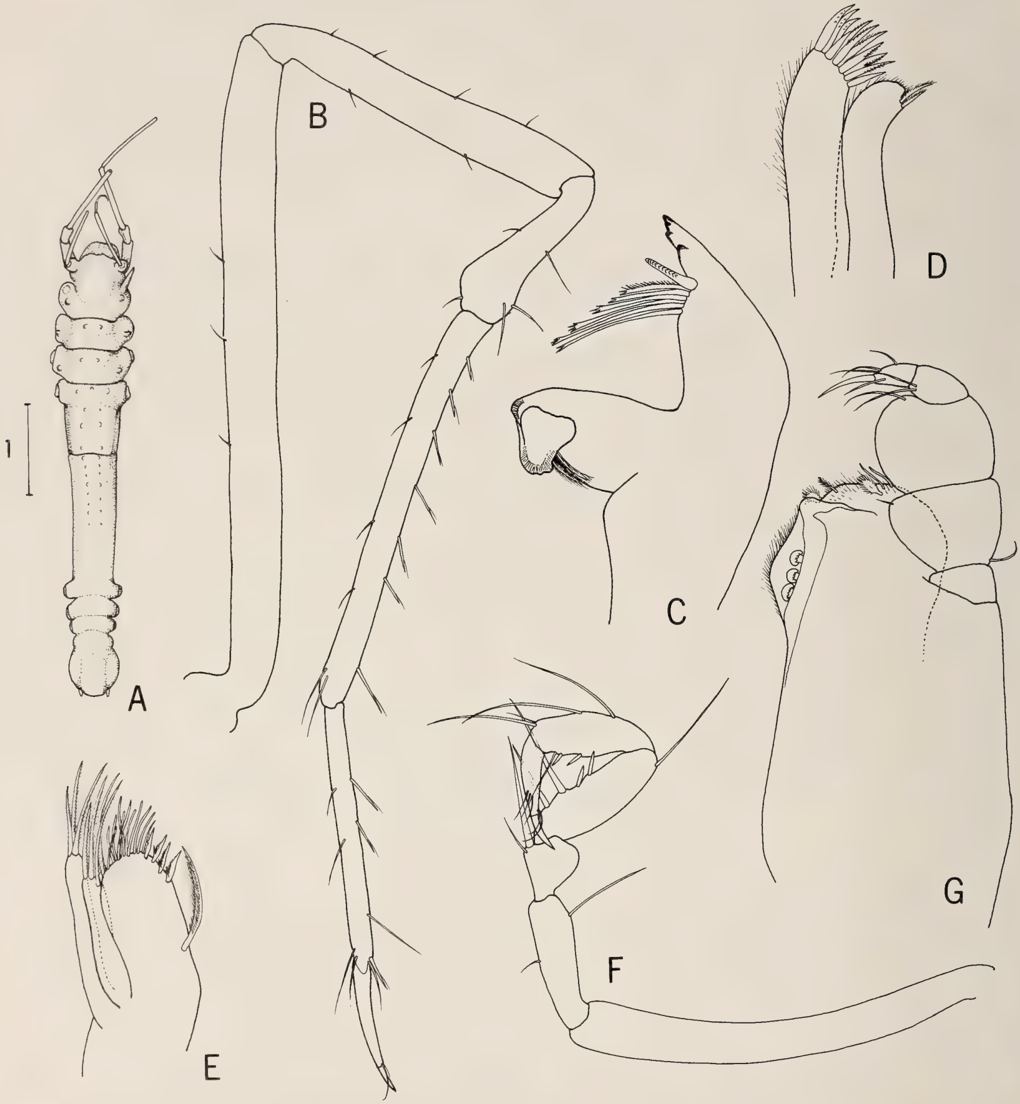

Fig. 41. *Haplomesus zuluensis* sp. nov. A. Holotype, dorsal view. B. Pereopod 7. C. Mandible. D. Maxilla 1. E. Maxilla 2. F. Pereopod 1. G. Maxilliped. Scale = 1 mm.

pleon. Latter oval-rounded, with central evenly convex area, posterior margin rounded.

Article 3 of antennule six times longer than article 4. Mandible lacking palp; molar distally broad, truncate. Maxilla 1, outer ramus with about eleven distal spines; inner ramus distally broadly rounded, with two fringed setae on medial margin. Maxilla 2 inner ramus with large double fringed seta on medial margin, several simple and fringed spines on rounded distal margin; inner lobe of outer ramus with four elongate distal fringed spines; outer lobe with three fringed spines. Maxilliped with articles 2 and 3 of palp broad, expanded, article 3 with medial margin evenly rounded; endite with strong median flange at right angles to endite surface, bearing three retinaculae. Pereopod 1, dactylus (including strong unguis) equal in length to propodus; latter with several elongate setae and two short spines on posterior (inner) margin; carpus slightly longer than propodus, with two short distal, and two elongate proximal sensory spines on posterodistal corner; basis slightly more than three times length of ischium. Pereopods posterior to pereopod 1 elongate slender, with few slender sensory spines on posterior margins of propodi and carpi. Marsupium formed by four pairs of oostegites on pereonites 1–4. Operculum almost circular, evenly convex. Uropod of single article barely extending beyond pleotelsonic apex.

Remarks

Haplomesus zuluensis shows some similarity to *H. quadrispinosus* (Sars), from the North Atlantic, in the integumental granulation and overall ornamentation, but the lateral spines of pereonite 1 are far more elongate in Sars's species. Using Wolff's key (1962) the present species runs down to *H. robustus* Birstein, but this North Pacific species is squatter and more granulate.

Etymology

The specific name is derived from the coastline adjacent to the area in which the species was collected, i.e. Zululand.

Ischnomesus Richardson, 1908

Ischnomesus glabra sp. nov.

Fig. 42

Material

Transkei. Holotype SAM–A17860, SM 247, 31°55′S 29°38′E, 1 800–1 950 m, 1 ♀, TL 4,0 mm.

Description

Female

Integument brittle, smooth, lacking ornament. Head with anterior margin convex, sunken into pereonite 1. Latter broadest part of body, anterolateral corners rounded. Pereonites 2–3 similar, broader than long. Pereonite 4 as wide as

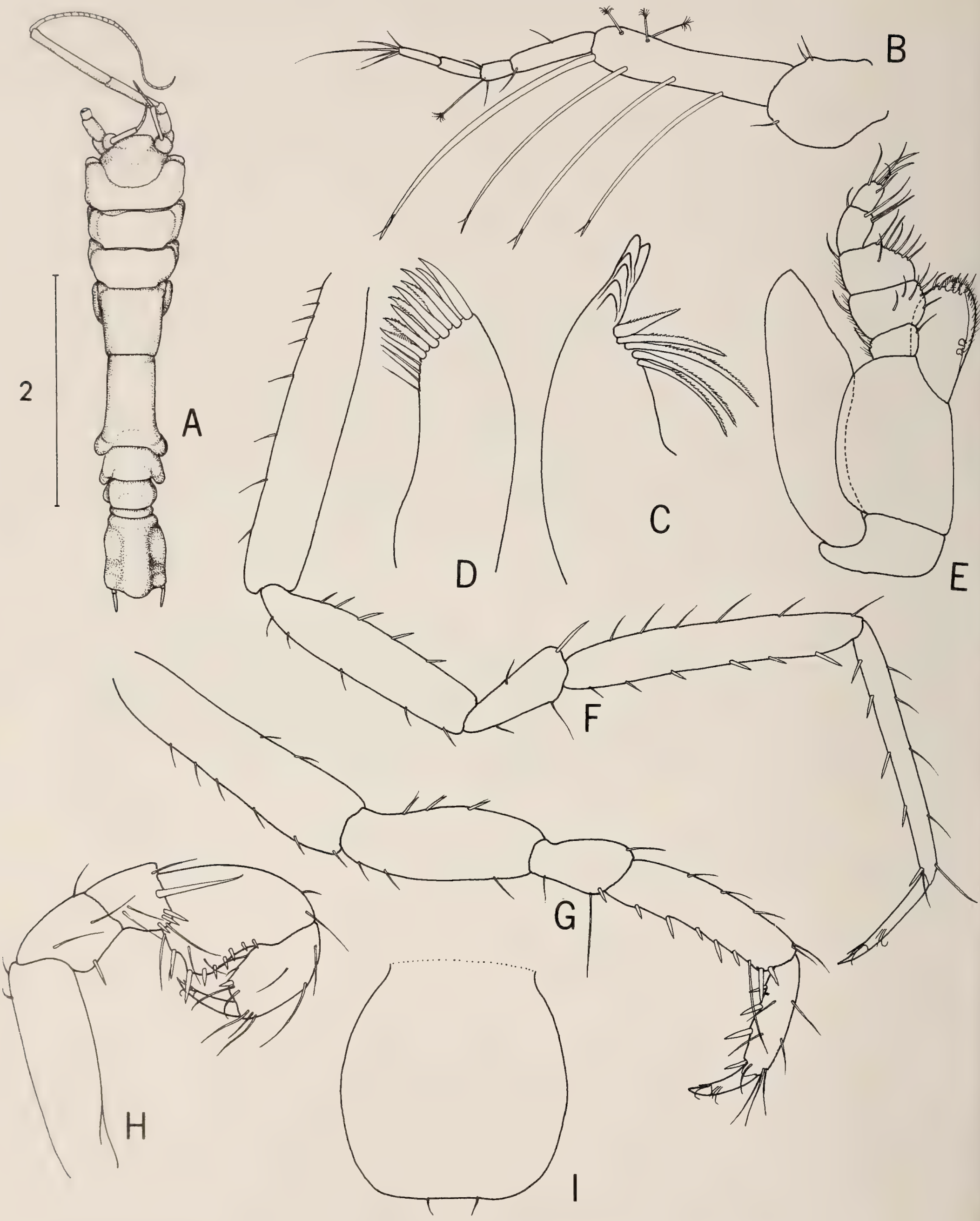

Fig. 42. *Ischnomesus glabra* sp. nov. A. Holotype, dorsal view. B. Antennule. C. Mandible. D. Maxilla 1. E. Maxilliped. F. Pereopod 7. G. Pereopod 2. H. Pereopod 1. I. Operculum, female. Scale = 2 mm.

long. Pereonite 5 longer than wide, about one and one-half times longer than pereonite 4. Pereonite 7 slightly shorter than pereonite 6. Pleon consisting of one very short free pleonite plus pleotelson; latter longer than wide, posterior margin between uropodal bases broadly convex.

Antennule with article 2 subequal in length to article 3 plus flagellum, bearing four elongate ventral sensory spines; flagellum of three articles. Antenna with two distal peduncle articles slender-elongate, article 5 about one-third longer than 4; flagellum of about thirty articles. Mandible lacking palp. Maxilla 1, outer ramus with nine distal spines. Endite of maxilliped not as wide as palp article 2, with two retinaculae on medial margin. Pereopod 1 considerably shorter than pereopod 2; dactylus claw-like, gently curved; propodus with distal truncate margin bearing single short spine; carpus distally widened, sinuous, armed with six short spines, posterior margin with two longer spines. Pereopod 2 slender, propodus and carpus bearing spines on posterior margins. Pereopods becoming more slender posteriorly, pereopod 7 with narrow dactylus, propodus and carpus; two latter articles with few short spines on posterior margins. Operculum broadly subcircular, distal margin slightly flattened. Uropod with basal article mostly concealed by dorsal pleonal margin, only slightly shorter than distal tapering article.

Remarks

Using Wolff's key to the species of *Ischnomesus, I. glabra* most closely resembles *I. anacanthus* Wolff, but the Tasman Sea species differs in having a relatively more elongate second antennular article, fewer distal spines on the outer ramus of maxilla 1, and the proportions of the maxillipedal palp are different. From Menzies' (1962*a*) key, the present species most closely resembles *I. simplissimus* from the South Atlantic, but this species possesses a mandibular palp, has a relatively longer second article in the antennule, and a pleon posteriorly subacute, rather than broadly convex. *Ischnomesus paucispinis* Menzies, from the South Atlantic, bears some resemblance to *I. glabra*, but has a relatively broader pleon bearing one stout and three small setae on the lateral border. *Ischnomesus vinogradovi* Birstein, 1963, from the north-western Pacific, lacks the broad spinose carpus of pereopod 1, and has a more narrowly rounded pleon.

Etymology

The specific name refers to the smooth, unornamented integument of this species.

Stylomesus Wolff, 1956

Stylomesus natalensis sp. nov.

Fig. 43

Material

Natal, south of Durban. Holotype SAM–A17861, SM 129, 30°53′S 30°31′E, 850 m, 1 ♂, TL 4,0 mm. Paratypes SAM–A17862, SM 117, 30°17′S 31°10′E,

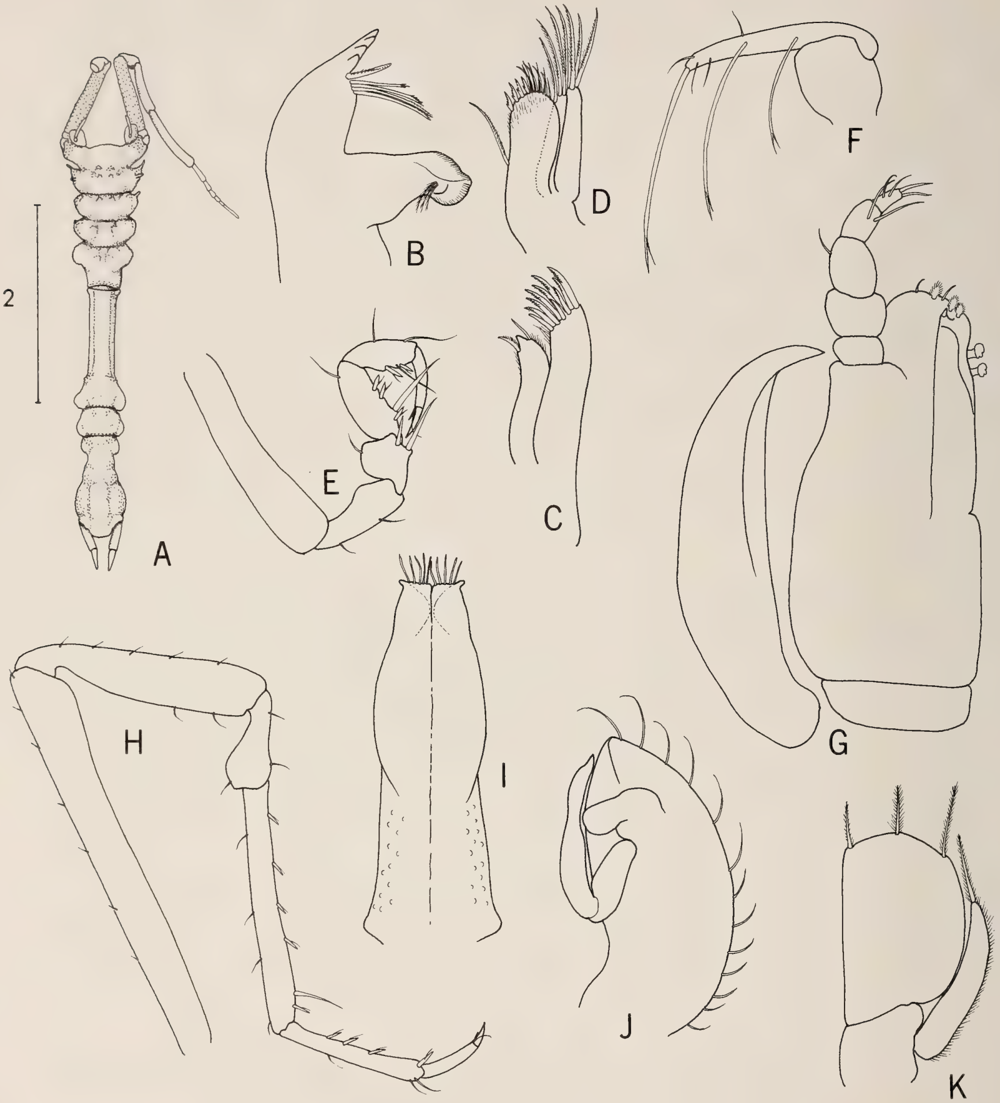

Fig. 43. *Stylomesus natalensis* sp. nov. A. Holotype, dorsal view. B. Mandible. C. Maxilla 1. D. Maxilla 2. E. Pereopod 1. F. Antennule. G. Maxilliped. H. Pereopod 7. I. Pleopod 1 male. J. Pleopod 2 male. K. Pleopod 3 male. Scale = 2 mm.

820 m, 1 ♀, TL 3,6 mm, 1 ♀ (damaged), 1 juv. Paratypes SAM–A17863, SM 123, 30°33′S 30°48′E, 690 m, 2 ♀, TL 4,0 mm, 4,0 mm. Paratypes USNM 189081, SM 129, 850 m, 2 ♂, TL 4,3 mm, 3,9 mm, 1 ovig. ♀ (damaged), 1 ♀.

Description

Male

Integument brittle, very finely granulate overall, granulations becoming coarser dorsally. Head with anterior margin gently convex, with two low submedian granulate tubercles near fusion line of pereonite 1. Latter with low submedian tubercles, laterally with short dorsal and dorsolateral spine (broken off in some specimens). Pereonite 2 with single short lateral spine. Pereonite 3 lacking lateral spine. Pereonite 4 about one-third length of pereonite 5; latter with cylindrical anterior part having double submedian longitudinal row of coarse granules. Pereonite 6 about one-fourth length of pereonite 5. Pereonite 7 fused with pleon. Lateral bulge indicates single pleonite fused with pleotelson. Pleotelson with central raised area demarked by irregular row of coarse granules, posterior margin evenly rounded.

Antennule with article 2 elongate, bearing three elongate sensory spines on ventral margin. Antennal peduncle article 2 elongate, densely granulate. Mandible lacking palp; molar distally broad, truncate. Maxilla 1, outer ramus with about ten distal fringed spines; inner ramus triangular between two distal setae. Maxilla 2, inner ramus with single strong fringed seta on median margin; four dentate and several simple spines on rounded distal margin; inner lobe of outer ramus with four fringed spines, outer lobe with three fringed spines. Maxilliped with palp article 2 broadest, but not markedly expanded; endite with flange at right angles to endite surface, bearing two aesthetascs, with short blunt spine at mediodistal angle. Pereopod 1 considerably shorter than following pereopods; dactylus with strong unguis; propodus with two spines on posterior margin; carpus slightly longer than propodus, posterior margin with two short distal spines and one elongate and one short spine proximally; merus with two elongate distal spines. Pereopods posterior to pereopod 1 slender-elongate, with short sensory spines on posterior margins of propodi and carpi. Pleopod 1, length two and one-half times basal width; distal margin truncate, armed with five setae on each ramus, and short blunt distolateral process. Pleopods 2 and 3 as illustrated. Uropod reaching well beyond pleotelsonic apex, of two articles, distal article shorter.

Female

Body essentially similar to male, but cylindrical part of pereonite 5 broader and lacking double submedian dorsal row of granules. Operculum subcircular, exposed surface granulate, rounded boss-like tubercle proximally near articulation.

Remarks

Stylomesus natalensis closely resembles *S. granulosus* Menzies, 1962*a*, from the South Atlantic, especially in the overall granulate integument, the form of the male pleopod 1 apex, and pereopod 1. Menzies' species, however, lacks spines on the anterior pereonites (although these have sometimes been broken off in the present material), and has a relatively more slender pereonite 5 (three times longer than wide), and a narrower pleon with a more produced posterior margin between the uropods. *Stylomesus simulans* Menzies has a posterior pereon and pleon similar to *S. natalensis*, but as the former was described only from posterior fragments, it is perhaps best not to associate the present material with it.

Etymology

The specific name refers to Natal, the coastline close to the type locality.

DISTRIBUTION AND ZOOGEOGRAPHY

The 1975–9 South African Museum's *Meiring Naude* cruises traversed the area from the southern Mozambique border to just south of East London. Apart from scattered deep stations occupied by the R.S. *Pieter Faure* at the turn of the century, and the transect off Still Bay to 200 m depths by the R.V. *Thomas B. Davie* in 1972–3, these cruises represent the only moderately comprehensive survey in relatively deep water on the southern African east coast. The ninety-two benthic stations ranged in depth from 40 to 1 950 m, i.e. from the shallow continental shelf to the continental slope (see Louw 1977, 1980), with most of the stations being in the 500–900 m depth range, i.e. in the steep lower shelf to slope area.

The results of these cruises, in terms of the isopods collected (including the data from six earlier papers), may be summarized in the following way: 81 species of identifiable isopods were collected; of these, 40 were described as new; 3 new genera, viz. *Agularcturus, Naudea*, and *Natalianira*, and 1 new family, the Bathynataliidae, were diagnosed. Of the 81 species, 14 have previously been recorded from off the west coast of South Africa; 9 occur from relatively shallow depths to more than 200 m, 4 species appear to be confined to depths of less than 200 m, and 1 species seems to be a true deep-shelf species, occurring in depths of more than 200 m.

The depth distribution of the 81 species may be categorized as follows: 29 species seem to be confined to depths of less than 200 m. Of these, only *Panathura serricauda*, and *Stenetrium crassimanus* (both from St. Paul and Amsterdam islands), have been recorded outside South African waters; 23 species occur from relatively shallow depths to lower shelf depths, with *Stenetrium saldanha* known from the St. Paul and Amsterdam islands, and *Spinianirella walfishensis* known from the Walvis Basin; 28 species appear to be confined to the lower shelf-slope depths, with *Bathycopea typhlops* known from the Irish Sea (North Atlantic), *Stenetrium abyssale* known from the Tasman Sea, and *Acanthomunna spinipes* known from the Antarctic.

From all three categories, therefore, only seven species have been recorded outside southern African waters. While to speak of an endemic fauna may be too presumptuous with regard to the deeper occurring species, it would certainly seem that there is a distinct endemic east-coast shallow-shelf isopod fauna.

ACKNOWLEDGEMENTS

My sincere thanks are due to the following individuals who assisted this project in various ways: the crew of the R.V. *Meiring Naude* and the staff of the Department of Marine Biology of the South African Museum for assistance during the cruises; the Director and Trustees of the South African Museum for permission to work on the material presented here; Miss Elizabeth Louw of the South African Museum for assistance with providing data and arranging loans of material; Dr H. Zibrowius of Marseille for providing arcturid material; Miss Helen Lew Ton of the National Museum of Victoria, Melbourne, for valuable discussion of arcturid taxonomy; Dr Klaus Rützler of the Smithsonian Institution for identifying sponge material; Miss Marilyn Schotte of the Smithsonian Institution for assistance with some of the arcturid illustrations; and Mrs Ione Rudner for her impeccable editing of the manuscript and proofs.

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Zur Strassen, O. 1902. Über die Gattung *Arcturus* und die Arcturiden der Deutschen Tiefsee-Expedition. *Zool. Anz.* **25**: 682–689.

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Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family **Nuculanidae**

Nuculana (*Lembulus*) *bicuspidata* (Gould, 1845)

Figs 14–15A

Nucula (*Leda*) *bicuspidata* Gould, 1845: 37.
Leda plicifera A. Adams, 1856: 50.
Laeda bicuspidata Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).
Nucula largillierti Philippi, 1861: 87.
Leda bicuspidata: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:
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semicolon separates more than one reference by the same author
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In describing new species, one specimen must be designated as the holotype; other specimens mentioned in the original description are to be designated paratypes; additional material not regarded as paratypes should be listed separately. The complete data (registration number, depository, description of specimen, locality, collector, date) of the holotype and paratypes must be recorded, e.g.:

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FISCHER, P.-H., DUVAL, M. & RAFFY, A. 1933. Études sur les échanges respiratoires des littorines. *Archs Zool. exp. gén.* **74**: 627–634.

KOHN, A. J. 1960*a*. Ecological notes on *Conus* (Mollusca: Gastropoda) in the Trincomalee region of Ceylon. *Ann. Mag. nat. Hist.* (13) **2**: 309–320.

KOHN, A. J. 1960*b*. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bull. Bingham oceanogr. Coll.* **17** (4): 1–51.

THIELE, J. 1910. Mollusca: B. Polyplacophora, Gastropoda marina, Bivalvia. *In:* SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika* **4**: 269–270. Jena: Fischer. *Denkschr. med.-naturw. Ges. Jena* **16**: 269–270.

(continued inside back cover)

ANNALS OF THE SOUTH AFRICAN MUSEUM
ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

Volume 93 Band
June 1984 Junie
Part 5 Deel

NEAR-SURFACE COPEPOD DISTRIBUTION IN THE SOUTH-WESTERN INDIAN AND SOUTH-EASTERN ATLANTIC OCEAN

By

A. H. B. DE DECKER

Cape Town Kaapstad

The ANNALS OF THE SOUTH AFRICAN MUSEUM

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Verkrygbaar van die Suid-Afrikaanse Museum, Posbus 61, Kaapstad 8000

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1, 2(1–3, 5–8), 3(1–2, 4–5, 8, t.–p.i.), 5(1–3, 5, 7–9),
6(1, t.–p.i.). 7(1–4), 8, 9(1–2, 7), 10(1–3),
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Kopieregnavrae aan die Suid-Afrikaanse Museum

ISBN 0 86813 056 7

Printed in South Africa by
The Rustica Press, Pty., Ltd.,
Court Road, Wynberg, Cape

In Suid-Afrika gedruk deur
Die Rustica-pers, Edms., Bpk.,
Courtweg, Wynberg, Kaap

NEAR-SURFACE COPEPOD DISTRIBUTION IN THE SOUTH-WESTERN INDIAN AND SOUTH-EASTERN ATLANTIC OCEAN

By

A. H. B. De Decker

South African Museum, Cape Town

(With 5 figures, 80 maps, and 2 tables)

[*MS accepted 27 September 1983*]

ABSTRACT

Continuous underway sampling of near-surface plankton by centrifugal pump over a total distance of nearly 26 000 nautical miles yielded 123 species of free-living copepods in 645 samples. Distribution maps of 80 species are presented, with comments on the physical environment, diel migration, standing stock, and species diversity. Interpretation of a number of distribution patterns is attempted with reference to major current systems.

CONTENTS

	PAGE
Introduction	303
Material and methods	305
Remarks on the hydrology	307
Diel migration	311
Settled volumes	312
Diversity	313
List of species	313
Distribution patterns	318
Maps	327
Acknowledgements	367
References	367

INTRODUCTION

Biological exploration of the oceanic crossroads south of Africa has not kept pace with recent advances in the physical oceanography of the area.

Research on the area's pelagic marine copepods, the most abundant and diverse group of the zooplankton, has been reviewed by De Decker (1962). Subsequent contributions were made by Fukase (1962), Senô *et al.* (1963*a*, 1963*b*, 1966), and Tanaka (1964) on transects between Antarctica and South Africa; by Kollmer (1963), Unterüberbacher (1964), Stander & De Decker (1969), Coetzee (1974), and De Decker & Coetzee (1979) in the northern Benguela Current; by Grice & Hülsemann (1967) south of Madagascar; by Carter (1977) in the Agulhas Current area; by De Decker (1968, 1973) and Hutchings (1979) in the southern Benguela Current and western Agulhas Bank; by Wiborg (1964) around Tristan da Cunha; and by Grindley & Lane (1979) around Marion Island.

Ann. S. Afr. Mus. **93** (5), 1984: 303–370, 5 figs, 80 maps, 2 tables.

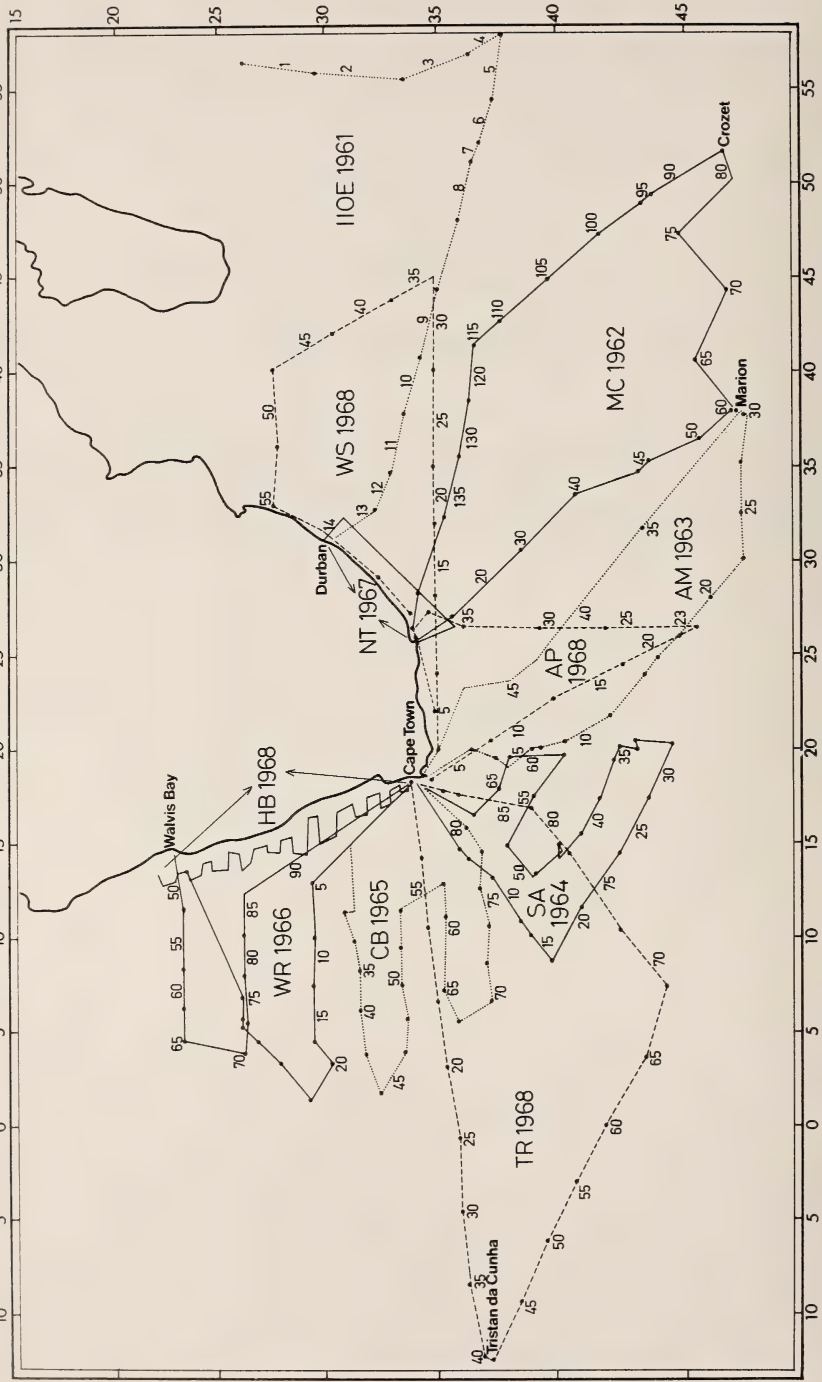


Fig. 1 Cruise tracks, with indications of the serial numbering of the samples.

As a whole, this research lacks methodological uniformity and spatial extension. The distributional data in the present report, although superficial in more ways than one, are an attempt towards a comprehensive and homogeneous biogeographical image of the complex environment surrounding southern Africa.

On the physical side, surface temperature imagery obtained by satellite, combined with trajectories of satellite-tracked buoys, revealed a wealth of detail about the dynamics of the surface waters and provided a unifying background for previous research. The relevant data and literature have been compiled and interpreted by Lutjeharms (1981*a–c*) and Lutjeharms *et al.* (1981).

Many of the distribution patterns shown in the present report agree well with the conceptual image derived from these physical studies; others point to aspects still in need of clarification.

MATERIAL AND METHODS

During the deep-sea cruises of R.S. *Africana II* in the years 1961 to 1968, a continuous sampler was used to collect plankton at keel depth while steaming between stations.

From 1961 to 1966 six oceanic sectors were surveyed at a rate of one every year, starting from the latitude of Maputo (26°S) in the Indian Ocean and proceeding clock-wise to the latitude of Walvis Bay (23°S) in the Atlantic (Fig. 1).

In 1967 and 1968 two areas not covered by these six cruises were visited, viz. the inshore waters along the south and south-eastern coasts between Cape Town and Durban comprising the Agulhas Bank, the core region of the Agulhas Current and the inshore upwelling along the south-eastern coast; and a 100 to 150 nautical miles-wide inshore belt along the west coast between Cape Town and Walvis Bay, where the Benguela coastal upwelling is the dominant feature. Also in 1968 three more deep-sea cruises were undertaken: one as far as Tristan da Cunha with a southward deviation across the Subtropical Convergence; one southward between the Agulhas Bank and the West Wind Drift; and the third to the east as far as the Madagascar Ridge (Fig. 1).

The total distance covered by underway sampling was close to 26 000 nautical miles, and the number of samples analysed was 645.

Table 1 gives some particulars about the cruises and the symbols used in this text to designate each cruise.

The continuous sampler consisted of a centrifugal pump conveying seawater through a pipe connecting an intake near the keel directly with a tap in the ship's laboratory. A 30 cm-long cylindrical straining sock of 200 μ mesh nylon gauze was fixed to the tap and ended in a removable bucket of the type used on the N70 Discovery plankton net (Kemp & Hardy 1929). The pump's capacity was approximately 30 l min.$^{-1}$.

The plankton retained in the bucket was removed at 4-hourly intervals or when the ship reduced speed on arriving at station, whichever was the shortest. The plankton obtained over each individual stretch was preserved in 4 per cent

TABLE 1

Data on cruises and collections.

Cruise	Dates	Samples examined	Copepod species identified	Settled volume ranges (% frequency) ml h^{-1}					Average standing stock (ml 1000 m^{-3})
				$<0,25$	to 0,50	to 1	to 2	>2	
IIOE 1961	4–15 July	16	68						
MC 1962	19 June–12 July	98	79	90	5	5			70
AM 1963	3–19 April	47	80	90	4	6			70
SA 1964	10–29 March	65	91	30	37	30	3		280
CB 1965	2–24 April	52	78	61	18	18	3		210
WR 1966	6–27 July	99	64	82	16	2			140
NT 1967	11–24 July	25	83	43	15	19	23		303
TR 1968	4–21 March	88	77	93	5	2			70
AP 1968	13–22 June	47	62						
WS 1968	4–22 Sept.	59	85	37	17	20	6		210
HB 1968	5–13 April	49	56	23	21	24	27	5	470

formalin, allowed to settle in a graduated cylinder for about 12 hours, and stored in a vial. Settled volume figures were converted to ml h^{-1}. While on station, the water delivered by the pump was allowed to run off in a sink, in order to have the system completely flushed before the continuous sampling resumed. The collecting bucket was replaced when the ship got under way.

Since normal cruising speed was 10 knots, each 4-hour sample contained plankton caught over a distance of 40 nautical miles, a unit length conferring sufficient resolution to the distribution patterns in an oceanic area stretching over more than 3 000 nautical miles longitudinally and nearly 1 500 nautical miles latitudinally. Reduced speed in bad weather enhances the resolution without affecting the catch figures, as these are based on time intervals, not on distances. During the 1961 cruise when the method was first attempted, starting from a station south of Mauritius, the catch was not subdivided in 4-hour sections, but each sample was taken from one station to the next, i.e. over approximately 100 nautical miles.

Copepods caught by the continuous pump suffered no more damage than those caught by a plankton net hauled at low speed. The pump, however, seems to be selective against larger plankton organisms such as salps, medusae, euphausiids, etc. It was repeatedly observed that in areas where all plankton nets, including those towed horizontally at or near the surface, were utterly clogged with salps at successive stations, the pump samples obtained under way between these stations contained hardly any salps. This selectivity is probably due to the low suction power of the pump having to contend with the inertia of organisms sweeping past the intake at a speed of 10 knots: the larger the organism, the less it will be affected by suction perpendicular to its relative motion. This interpretation is supported by the fact that large amounts of salps or euphausiids were sometimes caught in pump samples taken while the ship was stationary.

Selectivity against larger organisms is an obvious advantage when sampling is directed at small forms such as copepods, although it may affect the quantitative aspect of the results as larger copepods could well be affected by it to an unknown extent in relation to smaller ones.

Further advantages of pump sampling are its practicability in all weather conditions, the virtual elimination of the effects of plankton patchiness, the smaller likelihood of mixing different plankton communities in one sample, as can happen in vertical net hauls across a thermocline, the improved chances of capturing less abundant forms and, correlatively, of tracing a species to the limit of its distribution area where it becomes rarefied. Finally, this method does not impose delay on the ship and is not affected by loss of gear.

No attempt was made to obtain a complete repertory of all copepod species present. Non-identifiable juveniles were ignored and so were adults whose identification was uncertain or too time-consuming.

REMARKS ON THE HYDROLOGY

The hydrological conditions prevailing during individual cruises have been described in detail by Orren (1963, 1966), Duncan (1968), Visser (1969), Shannon & van Rijswijck (1969), Welsh & Visser (1970), and Henry (1972). Bang (1973) and Andrews & Hutchings (1980) gave detailed accounts of the Southern Benguela System; Duncan (1970) and Harris & Van Foreest (1977) presented a general interpretation of existing physical data on the Agulhas Current System. A conceptual image of the dynamics of the central part of the area under discussion, based mainly on satellite imagery, was constructed by Lutjeharms (1981*a*) (Fig. 2). The general outline of the physical structure of the seas around southern Africa has been repeatedly described and does not need to be given here. Only a few features which may be relevant to the interpretation of the plankton distribution patterns will be discussed; they are based on physical data collected during the cruises, with due regard to the picture emerging from some of the more recent publications mentioned above.

The SA cruise in March 1964 took place at the time when a short-circuiting in the *southern Agulhas Current retroflexion* had generated an extensive anticyclonic eddy or warm ring centered near the Schmitt-Ott Seamount at about 40°S 15°E, with a diameter of approximately 300 km (Fig. 3) and a depth in excess of 1 200 m (Fig. 4A). This eddy, called the 'Schmitt-Ott eddy' in the present context, has been described in detail by Duncan (1968) and Visser (1969). Lying astride the average latitude of the Subtropical Convergence, its effect on the latter was either an extensive southward displacement (beyond the survey area) or, more probably, a complete disintegration. The Agulhas Current proper ran southward along the 20°E meridian, to the east of the eddy.

The TR cruise in March 1968 crossed the area where the eddy had been 4 years earlier and passed over the Schmitt-Ott Seamount, but a warm ring was not found. Instead, a thermal front (the Subtropical Convergence) separated the Subantarctic surface water from a comparatively shallow and wide trough of

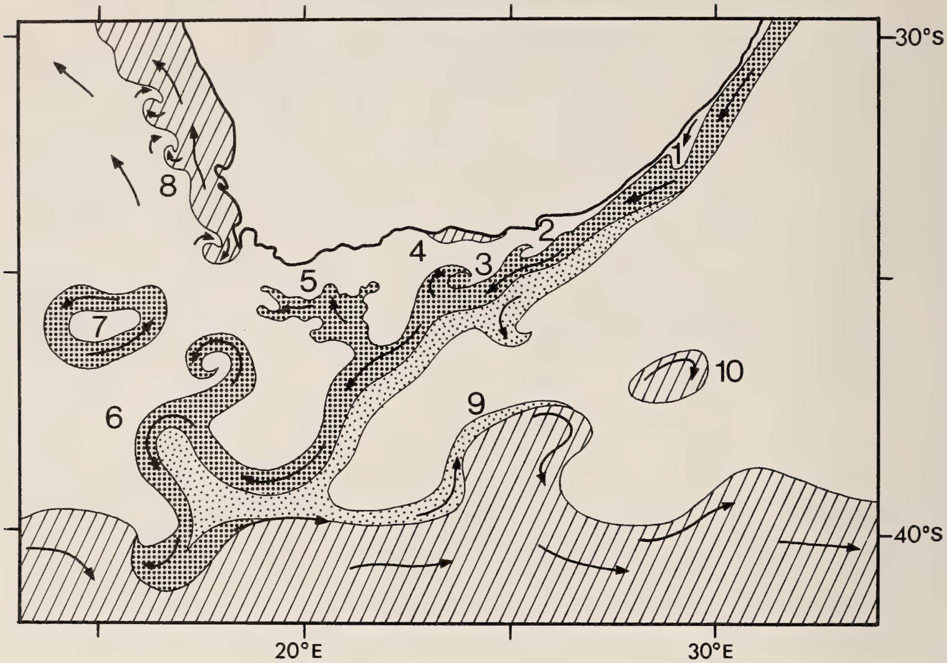


Fig. 2. A conceptual image of the Agulhas Current System. Heavy dots indicate warm water, lighter dots colder water, and hatching cold subtropical surface water and upwelled water. The line demarcating the subtropical water at about 40°S latitude is the Subtropical Convergence. 1. The embryonic stages of a Natal pulse. 2. Small waves or disturbances on the Agulhas Current border. 3. Shear edge effects, warm-water plumes or shear edge eddies. 4. Cold upwelled water. 5. The dispersion of a shear edge feature attached to an Agulhas Current meander. 6. The Agulhas Current retroflection. 7. An Agulhas Current Ring being advected northward. 8. The Cape upwelling regime with frontal eddies in evidence. 9. A planetary wave on the Agulhas Return Current–Subtropical Convergence. 10. An independent cold-water eddy spawned by an unstable planetary wave. (From Lutjeharms 1981*a*.)

warm saline water about 270 km north-east of the Schmitt-Ott Seamount, with a subsurface salinity maximum of 35,4‰ just below the 200 m level. As one crossing only was made, it is not possible to conclude from the single vertical section whether this trough represents a decaying warm ring or a terminal branch of the Agulhas Current (Fig. 4B).

Warm rings separated from the Agulhas Current near its retroflexion area are assumed to be moving northward over considerable distances in the south-eastern Atlantic. This view gained strong support, if not conclusive proof, from an experiment involving a satellite-tracked buoy placed in an Agulhas Current fragment detected on enhanced infra-red images received from Meteosat (Lutjeharms & Valentine 1981). A number of distribution patterns in the present report appear to illustrate this mode of advection of Indian Ocean species into the south-eastern Atlantic.

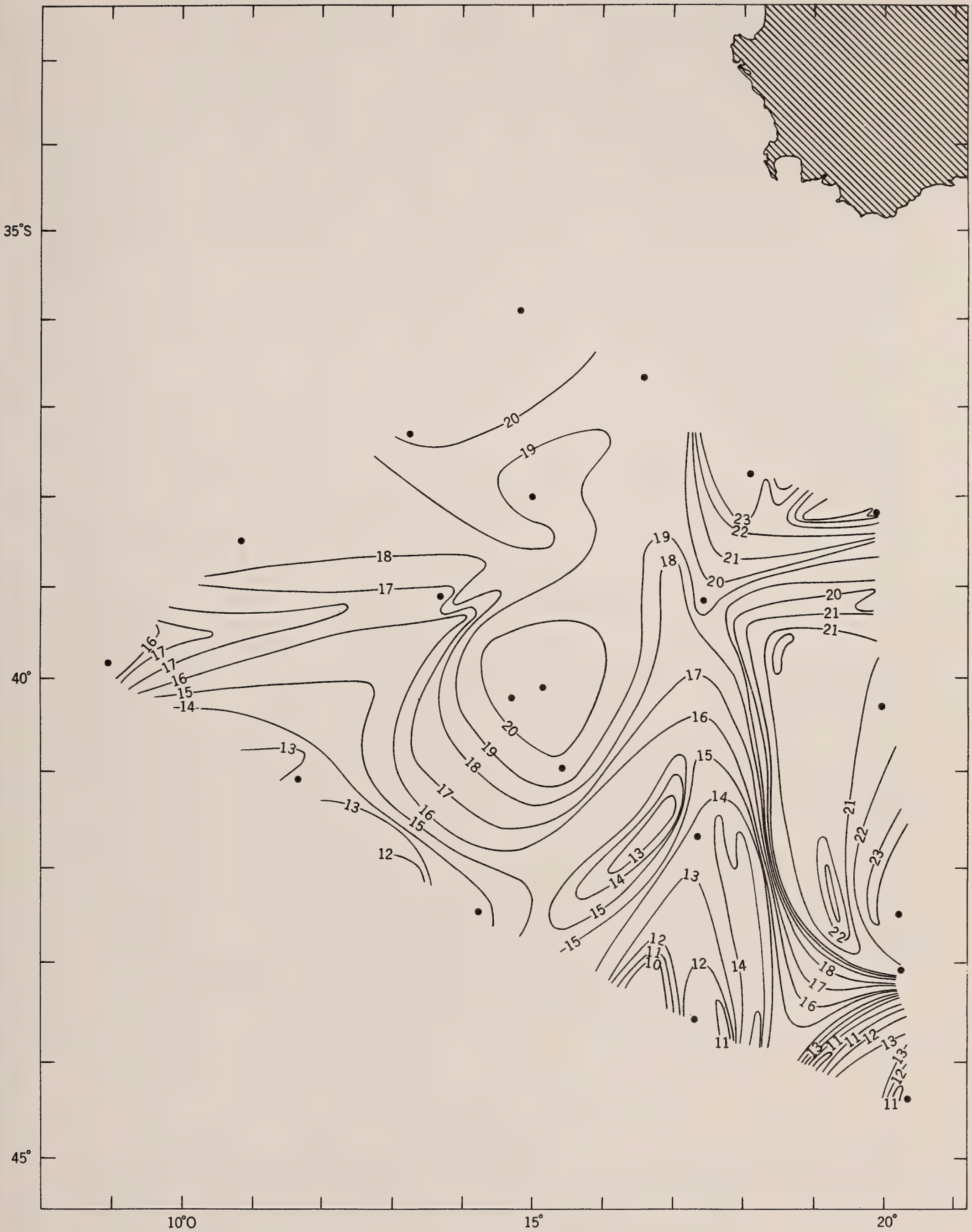


Fig. 3. Cruise SA 1964; sea surface temperature (°C) constructed from continuous thermograph recordings (from Visser 1969).

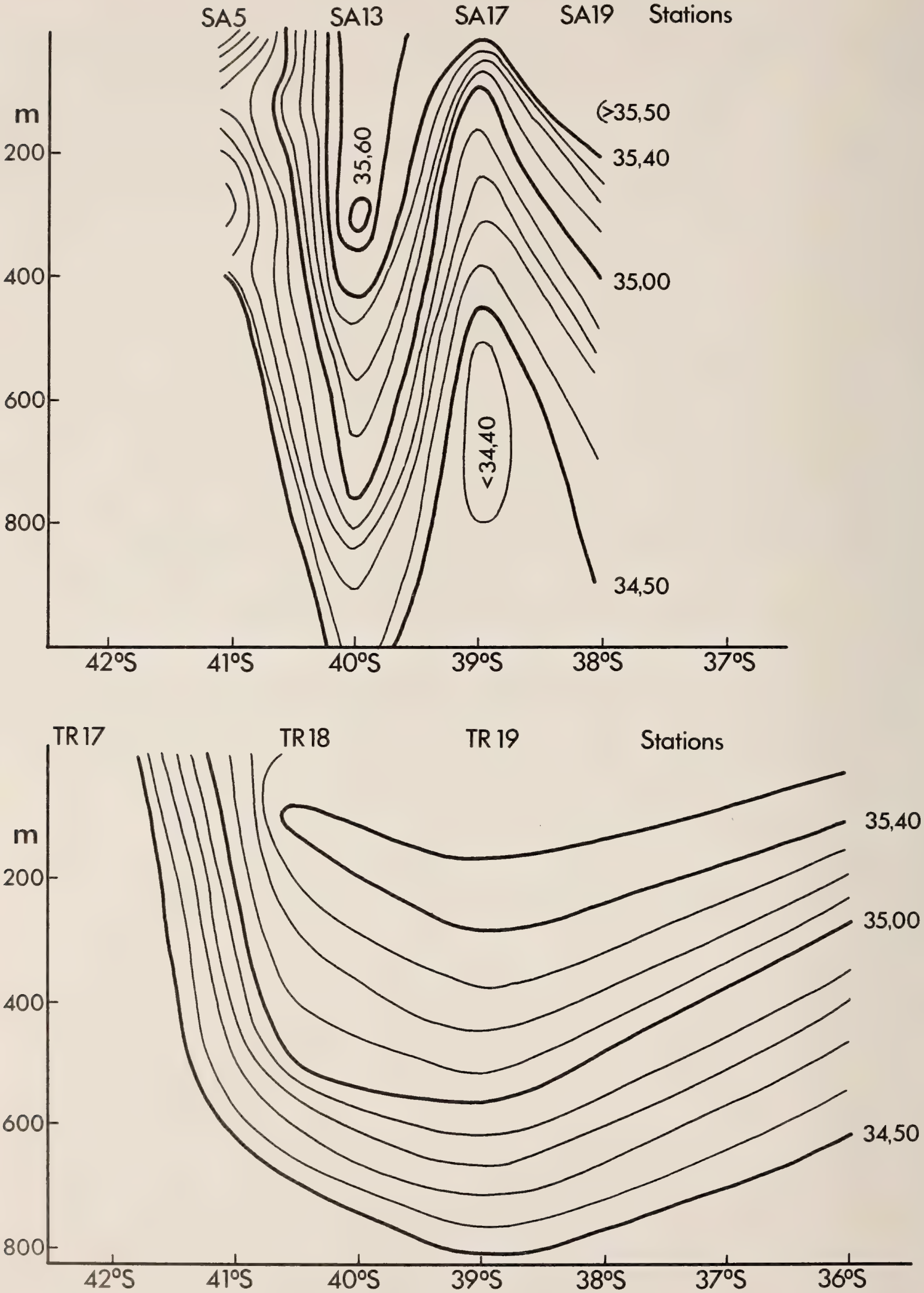


Fig. 4. A. Salinity section across the Schmitt-Ott eddy, cruise SA 1964.
B. Salinity section along the south-west to north-east leg of cruise TR 1968.

The *Subtropical Convergence* was crossed during the MC 1962 and AM 1963 cruises. Its location shows a discrepancy between the two cruises, which finds its counterpart in the discrepancy in the northern distribution limits of the Subantarctic copepod species during the successive visits. The species concerned seem to follow roughly the 5 to 6 °C isotherms. This observation agrees with the existence of planetary waves moving along the Convergence, as seen on satellite infra-red images (Lutjeharms 1981*a*). Some such waves may become unstable and lose their tops, which then become separate cold-core eddies drifting northward and advecting Subantarctic plankton into the notal and subtropical zones.

Along the *landward flank of the Agulhas Current*, cold low-saline water is often found at various places over variable distances, extending at times over a width of 20 km (Duncan 1970). According to present evidence, this surfacing of cold water has its predisposition in the near-permanent, steep upward trend of isotherms and isohalines against the slope to relatively shallow depths, and is basically the result of dynamic upwelling whenever a meander of the Agulhas Current swerves away from the coast, creating a divergence. Concomitant factors of this dynamic uplift may be atmospheric conditions such as south-westerly winds and cyclonic disturbances travelling up the coast. The resulting hydrological situation is a number of temporary cyclonic cells strung along the coast, whose inshore arcs cause northward advection of plankton and act in the manner of a conveyer-belt carrying surface-living cold-water organisms from the Agulhas Bank and west coast sometimes as far north as Cape St. Lucia (28°S). Deeper-living cold-water species find a near-permanent northward advection tunnel under the shallow thermocline created against the slope by the upward-trending isolines.

Hydrological conditions south of Madagascar have proved intricate and variable: apparent contradictions between the various workers may be due to seasonal reversals; year-round observations are not yet available from the area. The East Madagascar Current appears to behave like a western boundary current, retroflecting north-eastward after passing the southern tip of the island. In the process eddies are generated, some of which may migrate westward towards the Agulhas Current (Lutjeharms, Bang & Duncan 1981). Certain details in the distribution pattern of a few of the copepod species discussed below are reminiscent of such influxes from the direction of the Madagascar shelf.

DIEL MIGRATION

An indication of diel vertical migration was found when comparing 216 samples taken at night with 160 samples taken during daylight hours. The 28 species listed in Table 2 occurred in night samples in over 70 per cent of their total number of occurrence in both sets, and are therefore considered migrators.

TABLE 2

Diel vertical migration, as deduced from 216 night samples and 160 daylight samples.

	No. of occurrences	
	Total	% at night
Calanopia minor	3	100
Clytemnestra scutellata	10	100
Pleuromamma robusta	4	100
Heterorhabdus papilliger	33	97
Scolecithricella glacialis	14	93
Candacia simplex	12	92
Clytemnestra rostrata	11	91
Undeuchaeta plumosa	28	89
Centropages furcatus	9	88
Pleuromamma abdominalis	56	88
Euchaeta acuta	17	87
Pleuromamma piseki	116	86
Pleuromamma borealis	65	86
Rhincalanus nasutus	40	85
Undinula darwinii	13	85
Candacia bipinnata	14	85
Eucalanus elongatus	8	83
Pleuromamma gracilis	63	83
Candacia ethiopica	27	81
Euchaeta marina	35	80
Pleuromamma xiphias	19	79
Lucicutia flavicornis	111	77
Calanoides carinatus	22	76
Neocalanus gracilis	75	76
Metridia lucens	83	75
Calanus tenuicornis	89	74
Eucalanus subcrassus	15	73
Scolecithrix danae	31	71

Some species falling in the lower percentage range of night-time occurrence, even below 70 per cent, show increased abundance at night. Such species are *Calanus simillimus, Ctenocalanus vanus, Macrosetella gracilis, Microsetella norvegica, Calanoides carinatus, Clausocalanus ingens, Lucicutia flavicornis*, and *Metridia lucens*.

SETTLED VOLUMES

As the settled volumes were generally small—only 7 per cent of the samples exceeded 1 ml h^{-1}—a notable margin of error is attached to the recorded values. Nevertheless, a regional trend emerges when comparing the average settled volumes for the individual cruises (Table 1) or when mapping the areas where volumes of 0,5 ml h^{-1} or more were obtained occasionally.

These larger volumes are grouped near the continent and around the islands, as could be expected, and also in the Schmitt-Ott area and the neighbouring southern branch of the Agulhas Current. Since the percentage of night samples taken during the cruise in the latter area was much higher than during the other cruises, a possible bias was avoided by comparing only the night samples of the different cruises. This test confirmed the higher abundance of small zooplankton in the Schmitt-Ott area as compared with the surrounding areas.

DIVERSITY

The pattern of diversity—i.e. the number of species per sample—reflects the large-scale hydrological structure of the survey area (Fig. 5).

The diversity was lowest in the Subantarctic water and along the Benguela coastal upwelling. The transition to higher diversity in the South Indian and South Atlantic central gyres seems to occur somewhat further north in the Atlantic than in the Indian Ocean, in agreement with the average hydrological conditions for these areas as recorded in the '*Monatskarten*' published by the Deutsches Hydrographisches Institut (1960, 1971). Meisenheimer (1905) found a similar difference in the distribution limits of pteropods in both oceans and attributed it to warming by the Return Agulhas Current in the southern Indian Ocean.

Two patches of high diversity, based on three and four samples respectively, were found in the Atlantic and contained between 29 and 47 species per sample. One patch lay west of the Cape of Good Hope (TR 2, 3 and 4) and the other reached as far north as 31°S (CB 8, 9, 10 and 15). These patches contained assemblages in which the percentage contribution of Indian Ocean species decreased from the southern to the northern samples in the sequence 38, 32 and 36; 34, 28, 28 and 10 per cent respectively. Indian Ocean species are denoted as such in the present context on the basis of their distribution pattern obtained from the material under discussion. The diminishing presence of Indian Ocean faunal elements in a northward direction along the west coast lends support to the idea that the high diversity patches are manifestations of warm rings originating from the Agulhas Current and moving northward in the Atlantic. Four samples taken in the southward branch of the Current (SA 33, 56, 63 and 64) and containing a total of between 35 and 39 species had a percentage of Indian Ocean forms ranging between 28 and 40 per cent. Two samples with 36 species each, taken outside the Agulhas branch but close to its thermal front (SA 32 and 37) contained 20 and 22 per cent of Indian Ocean species, respectively.

One sample of 32 species taken in the Atlantic at 26°S 10°E at night (WR 81) did not contain Agulhas-related species.

LIST OF SPECIES

Occurrences of scarce and scattered species are indicated here by means of the cruise symbol followed by the sample number (see Fig. 1); occurrences of other species are shown on the maps that are placed in alphabetical order of species names on pages 327–366.

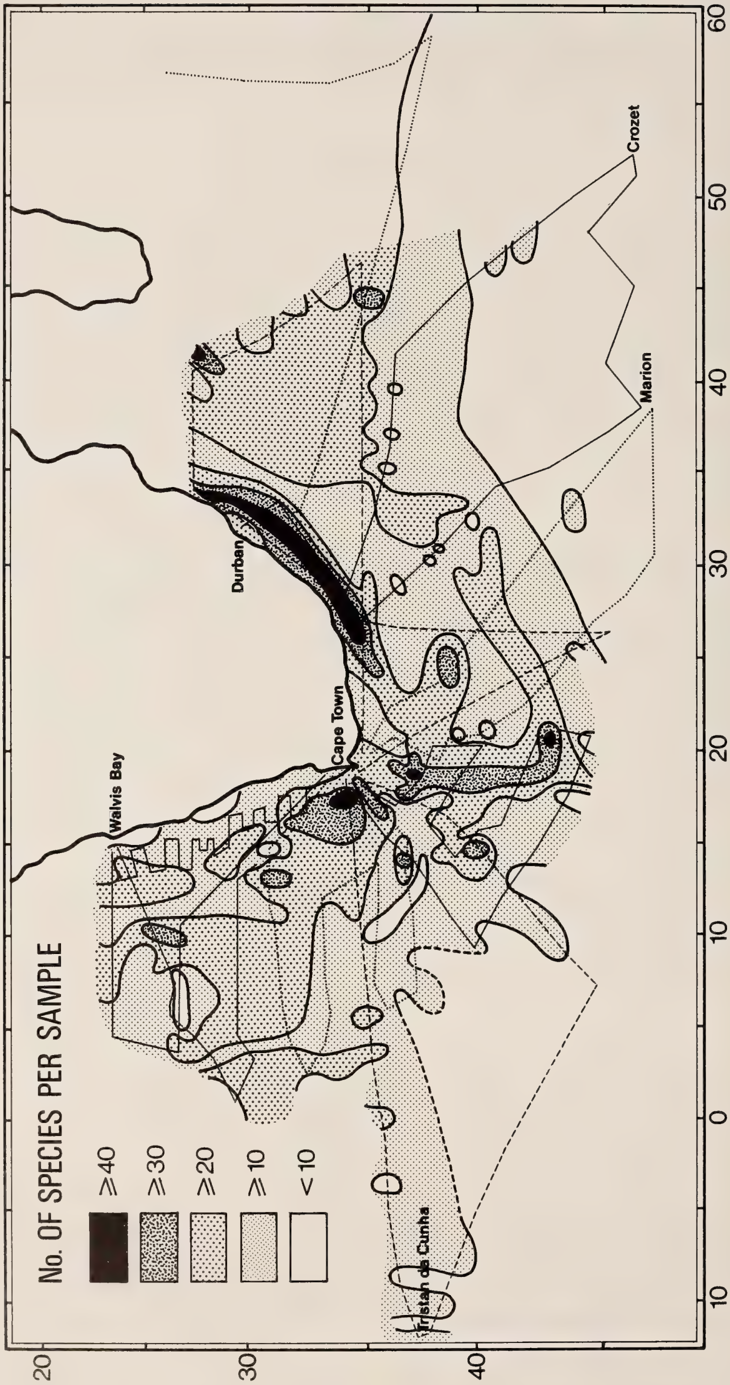


Fig. 5. Diversity distribution.

Thickened lines on the ship's routes indicate stretches where the species was found in the continuous pump samples. *Shaded areas* are suggested distribution patterns; darker shading indicates areas of higher abundance.

Order CALANOIDA

Family **Calanidae**

Calanus finmarchicus (Gunnerus, 1765) *s.l.* (*sensu lato*)
C. propinquus Brady, 1883 (AP 21)
C. simillimus Giesbrecht, 1902
C. tenuicornis Dana, 1849
Nannocalanus minor (Claus, 1863)
Calanoides carinatus (Krøyer, 1849)
C. macrocarinatus Brodski, 1972
Canthocalanus pauper (Giesbrecht, 1888)
Neocalanus gracilis (Dana, 1848)
N. robustior (Giesbrecht, 1888) (NC 136, 138)
Undinula darwinii (Lubbock, 1860)
U. vulgaris (Dana, 1849)

Family **Eucalanidae**

Eucalanus attenuatus (Dana, 1849) *s.l.*
E. crassus Giesbrecht, 1888
E. hyalinus (Claus, 1866)
E. longiceps Matthews, 1925 (TR 68)
E. monachus Giesbrecht, 1888 (SA 33)
E. mucronatus Giesbrecht, 1888
E. pileatus Giesbrecht, 1888
E. subcrassus Giesbrecht, 1888
E. subtenuis Giesbrecht, 1888 (MC 147; SA 3, 33; BC 8; TR 2)
Rhincalanus cornutus Dana, 1853
R. gigas Brady, 1883 (MC 78, 82)
R. nasutus Giesbrecht, 1888

Family **Paracalanidae**

Paracalanus aculeatus Giesbrecht, 1888
P. crassirostris F. Dahl, 1893
Acrocalanus gibber Giesbrecht, 1888
A. gracilis Giesbrecht, 1888
A. monachus Giesbrecht, 1888

Family **Calocalanidae**

Calocalanus contractus Farran, 1926
C. pavo (Dana, 1849)
C. plumulosus (Claus, 1863)
C. styliremis Giesbrecht, 1888
C. tenuis Farran, 1926
Mecynocera clausi I. C. Thompson, 1888

Family **Pseudocalanidae**

Clausocalanus furcatus (Brady, 1883)
C. ingens Frost & Fleminger, 1968
C. laticeps Farran, 1926
Ctenocalanus vanus Giesbrecht, 1888
Drepanopus pectinatus Brady, 1883

Family **Aetideidae**

Aetideus armatus (Boeck, 1872) (AP 3)
Euaetideus acutus (Farran, 1929) (MC 35; WS 46)
E. bradyi (A. Scott, 1909) (IIOE 14)
E. giesbrechti (Cleve, 1904) (CB 61)
Gaetanus minor Farran, 1905 (AM 4; HB 1)
Euchirella rostrata (Claus, 1866)
Undeuchaeta plumosa (Lubbock, 1856)

Family **Euchaetidae**

Euchaeta acuta Giesbrecht, 1892
E. biloba (Farran, 1929) (MC 69)
E. marina (Prestandrea, 1833)
E. media Giesbrecht, 1888 (IIOE 14)
E. wolfendeni A. Scott, 1909

Family **Scolecithricidae**

Scaphocalanus echinatus (Farran, 1906) (AP 15; WR 51, 52)
Scolecithricella glacialis (Giesbrecht, 1902)
Scolecithrix bradyi Giesbrecht, 1888 (SA 3, 29, 37, 44; WR 44; WS 31)
Scolecithrix danae (Lubbock, 1856)

Family **Phaennidae**

Phaenna spinifera Claus, 1863 (AP 10)

Family **Centropagidae**

Centropages brachiatus (Dana, 1849)
C. bradyi Wheeler, 1899
C. calaninus (Dana, 1849) (SA 33; IIOE 14)
C. chierchiae Giesbrecht, 1889
C. elongatus Giesbrecht, 1896
C. furcatus (Dana, 1849)
C. gracilis (Dana, 1849) (SA 3, 63; WS 46; IIOE 14)
C. longicornis Mori, 1937 (WS 54)
C. orsinii Giesbrecht, 1889 (WS 55)
C. violaceus (Claus, 1863)

Family **Pseudodiaptomidae**

Pseudodiaptomus nudus Tanaka, 1960 (AM 2; AP 1, 2, 3, 7)

Family **Temoridae**

Temora discaudata Giesbrecht, 1889
T. stylifera (Dana, 1849) (MC 147; SA 1, 2)
T. turbinata (Dana, 1849)

Family **Metridiidae**

Metridia lucens Boeck, 1864
Pleuromamma abdominalis (Lubbock, 1956)
P. borealis (F. Dahl, 1893)
P. gracilis (Claus, 1863)
P. piseki Farran, 1929
P. quadrungulata (F. Dahl, 1894) (AM 4; SA 61)
P. robusta (F. Dahl, 1894) (MC 69, 74, 75, 79)
P. xiphias (Giesbrecht, 1889)

Family **Lucicutiidae**

Lucicutia flavicornis (Claus, 1863)
L. gaussae Grice, 1963 (SA 45, 59, 63; TR 12; WR 79)
L. clausi (Giesbrecht, 1889) (AM 4)

Family **Heterorhabdidae**

Heterorhabdus papilliger (Claus, 1863)
H. spinifrons (Claus, 1863) (SA 46)

Family **Augaptilidae**

Haloptilus longicornis (Claus, 1863) (AM 4)
H. oxycephalus (Giesbrecht, 1889) (SA 46)
H. spiniceps (Giesbrecht, 1892) (WR 81)

Family **Candaciidae**

Candacia bipinnata (Giesbrecht, 1888)
C. bispinosa (Claus, 1863) (AM 3; SA 62; WR 41)
C. catula (Giesbrecht, 1889)
C. curta Cleve, 1904 (HB 13, 16, 34; MC 147)
C. ethiopica (Dana, 1849)
C. pachydactyla (Dana, 1849) (MC 147; CB 16; WS 7)
C. simplex (Giesbrecht, 1889)
C. truncata (Dana, 1849) (TR 2; IIOE 14)
C. varicans (Giesbrecht, 1892) (AM 36, 40, 46; TR 2, 5)

Family **Pontellidae**

Calanopia elliptica (Dana, 1849) (MC 147)
C. minor A. Scott, 1902
Labidocera acuta (Dana, 1849)
L. acutifrons (Dana, 1849)
L. minutum Giesbrecht, 1889
Pontella securifer Brady, 1883 (TR 85)
Pontellina plumata (Dana, 1849) *s.l.*

Family **Acartiidae**

Paracartia africana Steuer, 1915 (WR 47 to 52: Walvis Bay shelf)
Acartia amboinensis Carl, 1907 (WS 55)
A. danae Giesbrecht, 1889
A. negligens Dana, 1849

Order CYCLOPOIDA

Family **Oncaeidae**

Lubbockia aculeata Giesbrecht, 1891 (WS 50, 57)
L. squillimana Claus, 1863 (MC 20; AM 45; IIOE 1, 2)
Pachos sp. (IIOE 14)

Family **Sapphirinidae**

Corissa parva Farran, 1936 (IIOE 1)

Order HARPACTICOIDA

Family **Ectinosomatidae**

Microsetella norvegica (Boeck, 1864)
M. rosea (Dana, 1848)

Family **Tachydiidae**

Euterpina acutifrons (Dana, 1852)

Family **Clytemnestridae**

Clytemnestra rostrata (Brady, 1883)
C. scutellata Dana, 1847

Family **Miraciidae**

Miracia efferata Dana, 1846 (SA 1, 44, 63, 70)
Oculosetella gracilis (Dana, 1852)
Macrosetella gracilis (Dana, 1848)

DISTRIBUTION PATTERNS

The distribution patterns shown in this report are influenced by a number of time-dependent factors, the most obvious being shifting currents, eddies and fronts, and pulses of upwelling, among other physical and chemical conditions, as well as rhythmic events in the life of the species such as diurnal or seasonal migration. To give but one example: had the south-western sector been surveyed in October–November instead of in March, *Calanus tonsus* and *Calanoides macrocarinatus* would have been found at the surface over an extensive inshore area around the Cape of Good Hope (De Decker 1973).

One might expect that the lack of synopticity of the collections could have a disrupting effect on the distribution patterns. In most cases, however, no such effect has been noticed and meaningful patterns have been obtained, at least for species occurring with sufficient frequency. The reason for this may be that the environmental factors (currents, fronts, etc.) governing the dispersal of a species have a reasonable degree of topographical constancy at the scale of the area surveyed.

One exception can be seen in the species found south of the Subtropical Convergence. Here the planetary waves running along the Convergence may be responsible for the discontinuity in the patterns in successive years (MC 1962, AM 1963) and between SA 1964 and TR 1968, south of the Schmitt-Ott Seamount (see e.g. *Clausocalanus laticeps*).

No attempt has been made to force a biogeographical interpretation on species showing a rarefied and thinly scattered occurrence in the present material. Such species are either rare or have their habitat in deeper levels; their occasional capture at the surface can be considered merely incidental and offers no valid basis for a distribution picture.

The two most frequent types of distribution are:

(i) a widespread distribution mainly north of the Subtropical Convergence in warm and temperate waters, with avoidance of the cold coastal upwelling, and

(ii) patterns related to the Agulhas Current and its ramifications.

Widespread warm-temperate patterns

The southward extension of this group varies to a notable extent depending on the species. *Mecynocera clausi* advances farthest south, following the surface isolines of 34,30 ‰ salinity and 10 °C temperature; *Acartia danae, A. negligens* and *Nannocalanus minor* do not extend below 35,00 ‰ and 13 to 16 °C, whereas *Calocalanus pavo* and *C. plumulosus* are generally confined still further north. The southern limits of the above-mentioned species converge and practically coincide at two places where a strong thermohaline front was crossed: near station MC 3 (40°44′S 33°36′E) where the Subtropical Convergence manifested itself by a temperature gradient of 11 °C (18,5 to 7,5 °C) in less than 70 nautical miles along the north-western–south-eastern route with relatively little wind and current activity (Orren 1966, figs 2 and 5), and near station SA 9 (43°04′S 20°09′E) where the impact of the southward branch of the Agulhas Current on the Subantarctic Water of the West Wind Drift caused a drop in temperature of 10 °C in as many miles (Duncan 1968). At the latter position only *Mecynocera clausi* penetrates farther south than the other warm-temperate species.

The two widespread *Pleuromamma* species, *P. borealis* and *P. gracilis*, advance further south than any of the above-mentioned species, but being active diurnal migrators, their occurrences are scattered due to their absence from the daylight catches, and their southern limit is not well defined. South of the Subtropical Convergence they were caught less frequently. *Pleuromamma abdominalis, P. piseki* and *P. xiphias*—especially the latter—were not found as far south.

In most of the warm-temperate species the southern limit lies further north in the Atlantic than in the Indian sector. On the Atlantic Ocean a north-eastward trend of certain species is noticeable on the western flank of the Schmitt-Ott eddy, indicating penetration of Subantarctic Water in direction of the Cape. Within the Schmitt-Ott eddy, however, the warm-temperate species undergo their furthest southward advection.

Agulhas Current patterns

More than twenty species display a pattern more or less closely related to the course of the Agulhas Current and its ramifications. There is a gradation in tolerance of lateral mixing, some species keeping strictly to the warm core of the Current, while others show a more diffuse pattern.

Centropages furcatus shows a near-ideal picture of the course of the Current, a main branch reaching as far as 43°S, with a weak northern branch and some spillage into the Atlantic to the west. This species had long been considered as world-wide circumtropical, until Fleminger & Hülsemann (1973) showed that the mid-Atlantic population is a separate species, *C. velificatus* (de Oliveira, 1947). The specimens in the present material may be taken as Indo-Pacific indicators of the Agulhas Current.

Progressively wider dispersion away from the Current core is apparent in species such as *Acrocalanus gracilis, A. monachus, Temora discaudata, Eucalanus mucronatus, E. pileatus, E. crassus, Canthocalanus pauper,* and *Scolecithrix danae*, revealing structural details of the current, viz. a returning branch around 38°S, an eastward retroflexion of the main current in 42–43°S along the Subantarctic Surface Water, penetration of Agulhas Current water into the Atlantic with northward transport on the western side of the Benguela front, and colonization of the warm centre of the Schmitt-Ott eddy.

A most pervading indicator of Agulhas Current admixture is *Macrosetella gracilis*. It penetrates as far north as 30°S into the Atlantic, but has not yet been found in South West African waters, except for one specimen during the 1963 oceanographic anomaly reported by Stander & De Decker (1969). Its world distribution is circumtropical; in the south-western Atlantic it is an indicator of the Brazil Current (Björnberg 1959).

Agulhas Bank patterns

The Agulhas Bank appears to be the centre of dispersal for *Calanus finmarchicus s.l., Candacia bipinnata*, and *Centropages chierchiae*. The name *Calanus finmarchicus s.l.* is used here to designate a form of uncertain taxonomic status showing morphological resemblances with both *C. australis* (Brodski, 1959) and *C. pacificus pacificus* (Brodski, 1959). The various sibling species derived from the original *C. finmarchicus* stock appear to be concentrated (at least in the Southern Hemisphere) on and near shelf areas (Australia, Tasmania, New Zealand, Chile, Argentina, and Tristan da Cunha) but rare in the open ocean, as stated by Jillett (1971) in the case of New Zealand plankton. The Agulhas Bank form may well constitute a separate taxon, different from the varieties of *C. australis* recorded in similar latitudes off Australia, New Zealand and South America but, like these, falling into the *C. helgolandicus*-group.

Candacia bipinnata was found by Lawson (1977) in large numbers off the Somali coast and considered a good indicator of coastal upwelling conditions there. Unpublished data about the Benguela upwelling show that the latter opinion needs qualification if applied to southern African conditions: Unterüberbacher (1964) did not find the species during his year-round survey in the Walvis Bay upwelling area, whereas one single specimen was found in the same area by Stander & De Decker (1969) during the 1963 oceanographic anomaly.

An isolated occurrence of *Calanus finmarchicus s.l.* and *Candacia bipinnata* in two different, but close, neighbouring samples south-west of Madagascar supports the suspicion that the Madagascar shelf could harbour these species, whose appearance in the far north-eastern corner of the present survey area would be due to advection by the East Madagascar Current or by migrating eddies generated at its retroflexion. The presence of *Candacia bipinnata* in the waters around Madagascar has been reported by Binet & Dessier (1968) for the Nosy-Bé area and by Lawson (1977) for the Mozambique Channel and the southern tip of the island.

Centropages chierchiae appears to be more tolerant than the two previous species and is therefore a good indicator of advection. It avoids the cold upwelled water off the west coast and generally appears to be entrained by the mixed waters bordering the main stream of the Agulhas Current. The species starts following the ramifications of the Current from the moment the latter reaches the eastern flank of the Agulhas Bank. Along the east coast of South Africa it is found in the cooler inshore belt and is practically absent from the Agulhas Current proper, in the same way as can be seen in some other species, e.g. *Calanus finmarchicus s.l.* and *Calanoides carinatus*.

In the south *Centropages chierchiae* is advected along the southward branch of the Agulhas Current, whereas in the Atlantic it spreads in a manner similar to the Agulhas Current species *Macrosetella gracilis*, but further west and north.

The distribution of *C. chierchiae* is clearly dictated by the dynamic effect of the various branches of the Agulhas Current on the surrounding waters, although it does not belong to the fauna of that Current. Its areas of higher concentration are also clearly different from those of *Macrosetella gracilis*. A similar effect on the distribution of species not belonging to the Agulhas Current community is seen in cases such as *Calanoides carinatus, Candacia ethiopica, Centropages brady, Eucalanus attenuatus, Labidocera minutum, Rhincalanus cornutus, R. nasutus,* and *Temora turbinata*.

In the literature *Centropages chierchiae* is considered a tropical and subtropical Atlantic species (Vervoort 1965). Its distribution pattern in South African waters suggests that it is a form of mixed water, preferring higher temperatures than its congener *C. brachiatus*, which lives inside the colder belt of coastal upwelling. Available literature data about *C. chierchiae* convey the impression that the species is essentially neritic (see Bainbridge 1972), like many other *Centropages* species, but the distribution pattern emerging from the present survey suggests that it can withstand advection over considerable distances, as do some other neritic forms, e.g. *Temora turbinata* (Bradford 1977; De Decker & Coetzee 1979).

The small patch of *C. chierchiae* off Walvis Bay could be an outpost of a northern population of the species extending from the Moroccan coast (Furnestin 1957) southward along the coast as far as Angola (Marques 1953, 1958; Bainbridge 1960*a*, 1960*b*; Vervoort 1965; Neto & Paiva 1966; Corral 1970, Corral & Corral 1970) and occasionally carried towards the vicinity of Walvis Bay by the warm Angola Current (Unterüberbacher 1964; Stander & De Decker 1969). Several years' unpublished data at the author's disposal do not show a single instance of continuity between the west African and the South African populations of *C. chierchiae*.

Benguela Current patterns

Centropages brachiatus is most typical of the Benguela Current System and one of its most abundant copepods. Its world distribution is limited to certain areas of coastal upwelling, mainly in the Southern Hemisphere: it is a dominant species in the Peru Current (Björnberg 1973) and is also present, but less abundantly, over the Atlantic shelf of South America (Ramirez 1966, 1969; Björnberg 1963).

Like most *Centropages* species, it is essentially neritic and, contrary to *C. chierchiae*, it thrives in the cool upwelling belt hugging the shoreline between the Cape and the northern outskirts of the Namib Desert. The sinuosity of its main distribution boundary to the west reflects the general trend of the depth contours, as in the case of *Calanoides carinatus* (see below). Its scattered occurrences west of the thermal front may be the expression of cool frontal eddies spawned by the Benguela System. The 500 nautical miles-long extension of the distribution area west of Cape Town is difficult to explain: it appears to be connected with some dynamic process as a similar westward trend can be seen to a variable extent in that area in the patterns of *Acrocalanus gibber, A. gracilis, Calanus finmarchicus s.l., Centropages chierchiae, C. furcatus, Euterpina acutifrons*, and *Temora turbinata*, and was observed mainly in samples collected during the TR cruise in March 1968. Two distribution maps of surface temperatures obtained by satellite in May–June 1966 and in 1970 have been published by Szekielda (1972). They show a cold patch centered about 300 nautical miles due west of Cape Town in approximately the same position as the westward extension of *Centropages brachiatus* and the other species named above. A similar hydrological configuration was found during March 1969 in the form of a cold-cored, low-salinity anticyclonic vortex of about 200 nautical miles in diameter west of Cape Town, and on 9 February 1977 a similar feature in much the same position was detected on an infra-red image (Harris & Van Foreest 1977).

Apart from this isolated case of long-distance advection, *C. brachiatus* does not seem to withstand distant transport: the massive southward advection shown by *C. chierchiae* is indicated only faintly by *C. brachiatus*, whereas the penetration into the Indian Ocean, conveying a number of west coast species up the Natal coast by way of the inshore upwelling cells dotting the south-eastern coastline, is attested in the case of *C. brachiatus* merely by its occurrence off Durban in a single sample.

Northwards *C. brachiatus* does not appear to reach as far as Angola: neither Marques nor Neto & Paiva recorded it. Its only mention further north is by Rose (1929)—Mauretania, Canaries, Azores (authorities not named). The record from the Gulf of Guinea by Scott (1894) was proved erroneous by Bainbridge (Vervoort 1965). Recent investigations in the north-west African Atlantic by Corral (1970, 1972), Corral & Corral (1970) did not confirm the presence of *C. brachiatus* in these parts.

De Decker's (1962) suspicion that Cleve (1904) misidentified *C. brachiatus* as *C. typicus* in his South African material has been proved correct on examining Cleve's specimens in the collections of the South African Museum at Cape Town.

Calanoides carinatus is one of the main components of the zooplankton in the Benguela Current System, along with *Centropages brachiatus* (Unterüberbacher 1964; Hutchings 1979), but may be less abundant in the samples under discussion because of its preference for deeper levels; the gaps in its occurrence along the west coast sampling track (HB cruise) are caused by diurnal vertical migration.

Like *Centropages brachiatus, Calanoides carinatus* proliferates in upwelling areas, but in the Benguela Current System it seems to occur at lower temperatures than those favoured by *Centropages brachiatus*. On a world-wide scale, however, it appears to be more eurythermic than *C. brachiatus*: in tropical coastal upwellings such as those in the Gulf of Guinea (Bainbridge 1972; Mensah 1974), along the south coast of Arabia (Vinogradov & Voronina 1962; Gapishko 1968; Grobov 1968), and off Somalia (Smith 1982), *Calanoides carinatus* occurs in water temperatures between 18 and 25 °C, which are the local minima. Such eurythermy may explain the extensive southward and north-eastward advection sustained by this species in the survey area, in contrast to *Centropages brachiatus*. The latter has never been recorded off Angola, whereas Marques (1953, 1956, 1958) established the presence of *Calanoides carinatus* in sizeable quantities along the whole Angolan coast as far north as Cabinda. Neto & Paiva (1966) found it practically all year round in Baía Farta (12°36′S). Data of the occurrence of *C. carinatus* along the whole Atlantic coast of Africa have been summarized by Thiriot (1977).

The near-continuous occurrence of *Calanoides carinatus* along the southern leg of the 1968 WS cruise is puzzling. In this connection it may be noted that the author, having examined large numbers of *Calanoides* specimens taken at various depths all around southern Africa, has serious doubts about the taxonomic homogeneity of the representatives of this genus in the area concerned, apart from the seasonally occurring *C. macrocarinatus*. The still problematic *C. natalis* Brady comes to mind in this context.

Metridia lucens, another abundant form in the Benguela Current System, differs fundamentally from both species mentioned above in that its surface distribution appears to form a direct link between the west coast upwelling and the Subantarctic. Its presence in the Marion–Crozet region agrees well with the findings of Seret (1979) around the Crozet and Kerguelen islands, those of Hardy & Gunther (1935) around South Georgia, and of Ealey (1956) at Heard Island. Although more cryophilic than *Calanoides carinatus* and *Centropages brachiatus*, the occurrence of *M. lucens* in surface samples off the west coast of southern Africa extends further into the warm surface water beyond the Benguela front. This can be explained by the extensive diurnal vertical migration of *Metridia*: whenever the thermocline lies at a depth within the migratory range of this organism (i.e. a few hundred metres), *Metridia* may be found near the surface at night.

The isolated occurrence of *M. lucens* near Durban is another instance where east-coast upwelling manifests itself. Other species showing a similar occurrence are *Calanus finmarchicus s.l., Candacia bipinnata, Centropages brachiatus, Clytemnestra scutellata, Ctenocalanus vanus*, and *Euchaeta wolfendeni*. The biological effects of the east-coast inshore upwelling seem to be regular, more intense, and longer lasting in the Durban area than elsewhere along this coast. One may draw attention, in this connection, to the phenomenon called 'Natal pulse' by Lutjeharms (1981*a*), whereby large deflections of the Agulhas Current away from the coast appear to be initiated in the Natal Bight, inducing corresponding dynamic upwelling inshore.

Seret (1979) distinguished two size groups of *M. lucens* in her material from Kerguelen. Size measurements were not made on the material discussed here, but the author did notice some subtle differences among the specimens taken in the southern part of the survey area; the lateral profile of the head and the shape of the fifth thoracic segment were closer to *M. gerlachei*. A detailed account of this difference will be rendered elsewhere.

The three species discussed above, although dominant members of the zooplankton assemblage of the Benguela Current System (Unterüberbacher 1964; Hutchings 1979), have little else in common biogeographically in the eastern Atlantic. *Centropages brachiatus* is limited to the coastal upwelling belt and its close vicinity between the Cape and the northern part of South West Africa; it is neritic epiplanktonic. *Calanoides carinatus* stretches along the whole length of the African Atlantic, living in mesopelagic depths, probably along the slope, and migrating to the surface and inshore during the upwelling season (Thiriot 1977, 1978). *Metridia lucens* extends northward from the Subantarctic to south of Angola; its abundant North Atlantic population extends southward along the African coast and peters out in the latitude of Gambia (Kornilova 1967; Thiriot 1978).

Subantarctic patterns

Calanus simillimus and *Clausocalanus laticeps* have a clearly Subantarctic distribution, but they display great discrepancies between their occurrences during successive cruises.

Along the eastern leg of the AM cruise (April 1963), they were found 300 to 400 nautical miles further north than the neighbouring western leg of the MC cruise (June 1962), apart from an isolated northern patch along the latter leg. A similar difference in latitudinal position existed between both legs of the MC and AM cruises.

During the SA cruise (March 1964) both species were completely absent from the survey area, which extended beyond 44°S, but the TR cruise (March 1968) showed their presence in the same area even to a point slightly further north than the position of the warm core of the large anticyclonic eddy found in 1964 at 40°S.

These discrepancies can be explained by the existence of planetary waves of the same order of magnitude along the Subtropical Convergence and by the transient character of the eddies generated at the retroflexion of the Agulhas Current (see *Remarks on the hydrology* p. 307).

Scolecithrix glacialis occurred at the southern outskirts of the survey area only in water temperatures below 12 °C; between Marion and Crozet islands, in water temperatures below 6 °C, it was somewhat more abundant than elsewhere. Near the upper limit of its temperature range the species was found in night catches only.

The neritic Subantarctic species *Drepanopus pectinatus* shows an amazing oceanic dispersal extending over 300 nautical miles to the north of its normal occurrence on the shelf of the Crozet Islands: it was found in a continuous series of fourteen samples, in quantities of up to twenty specimens per sample, as against several hundred per sample in the neighbourhood of the islands. According to Orren (1966), a northward current was observed at stations between the Crozet Islands and latitude 41°S. An isolated record of *D. pectinatus* still further north, and around 39°30′S, coincides with an upwelling mentioned by Orren (1966: 7, figs 8, 11).

The complete absence of this species from the surroundings of Marion and Prince Edward islands is the more intriguing as it also failed to turn up in the material of Grindley & Lane (1979), who examined fourteen samples taken near these islands by vertical WP II-net hauls between 300 m and the surface in March and November 1976. This record of absence appears to be unique among the Subantarctic islands investigated to date (Bayly 1982).

Notal patterns

Clausocalanus ingens, although widespread, ostensibly avoids temperate extremes. It is absent both from the coldest inshore part of the west coast upwelling and from the warm southern branch of the Agulhas Current. In the eastern part of the Indian sector it shows a zonal trend in the middle latitudes (approx. 35 to 42°S) corresponding roughly to water surface temperatures between 10 and 20 °C. In the Atlantic sector the isolines of temperature and salinity are deflected north-eastward against the continent (see Deutsches Hydrographisches Institut *Monatskarten*) and so is the northern boundary of *C. ingens*; the small area in the south where the species was absent during the TR cruise lay slightly south of the 10 °C surface isotherm (Henry 1972). The zonal, circumglobal distribution of this species is clearly shown by Frost & Fleminger (1968, chart 3), but dearth of samples from the south-eastern Atlantic prevented these authors from documenting a north-eastward trend in its distribution in that area.

Calocalanus tenuis shows a zonal pattern of a similar type to, but much more restricted than, that of *Clausocalanus ingens*; the Schmitt-Ott eddy disrupts the pattern. Hutching's (1979) intensive survey of the Cape Peninsula upwelling showed that *Calocalanus tenuis* is linked with frontal conditions and is most abundant in the presence of strong thermoclines.

Two more species have a pattern suggesting zonality: *Oculosetella gracilis* and *Undeuchaeta plumosa*. It should be kept in mind, however, especially in the case of the latter species, that the present records concern only near-surface patterns of distribution: *U. plumosa* is well known as an inhabitant of deeper water over vast areas of the oceans. Its zonal distribution at the surface, if confirmed, could be linked with some physical or biological factor as yet unidentified, e.g. the absence of a pycnocline between its deep habitat and the surface.

The pattern of *O. gracilis* is in perfect agreement with the map presented by Lang (1948, fig. 314) and the record of Vervoort (1957) south of Tasmania, while confirming the notal distribution of this species over an added 1 500 nautical miles in the south-western Indian Ocean.

The remarks concerning the surface distribution of *Undeuchaeta plumosa* also apply in the case of *Calanoides macrocarinatus* and *Calanus tonsus*. Though scarce and widely scattered, their occurrences show a degree of similarity in that three out of the four or five patches of occurrence of the one species lie in close proximity to three of the other, viz. south-east of the Schmitt-Ott eddy, near or on the shelf off Port Elizabeth, and over the Madagascar Ridge in about 35°S latitude.

The distribution and life cycle of both species, as recorded in the literature and in unpublished documentation on the South African plankton, appear to have much in common.

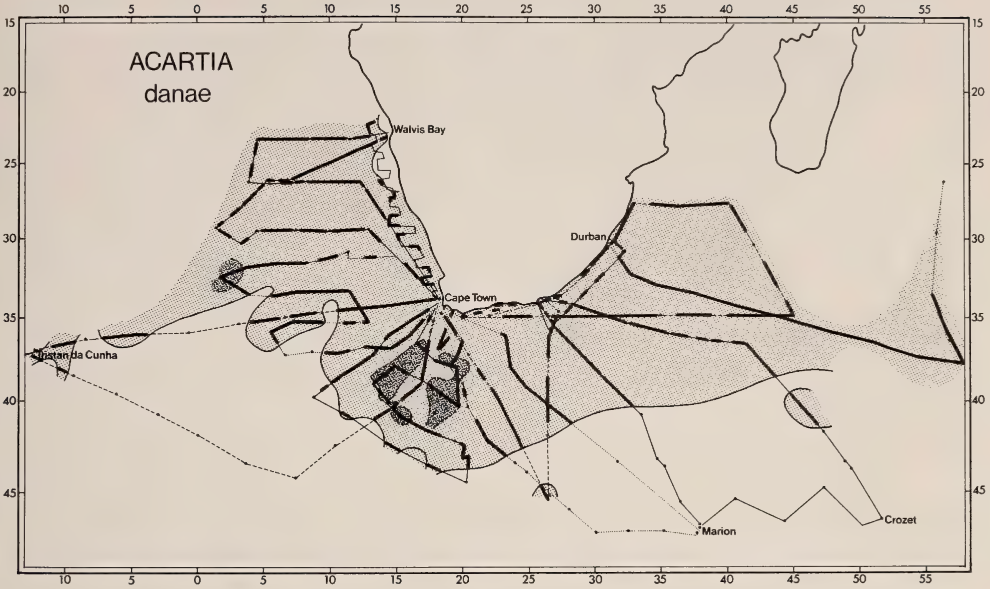
Brodski (1972) is probably right in assigning *Calanoides macrocarinatus* to the Notal zone.

Calanus tonsus is typical of the Subantarctic Water (Vervoort 1957; Tanaka 1960, 1964; Senô *et al.* 1963*a*, 1963*b*). Jillett (1968), working in southern New Zealand waters near 46°S, noted that the species appeared closely associated with the Subtropical Convergence and that it executed extensive seasonal vertical migrations, appearing near the surface in large numbers from September to January. De Decker (1973), on the basis of unpublished data, mentioned the appearance of *C. tonsus* and *Calanoides macrocarinatus* in the surface water close to the south and west coasts of South Africa, also from September to January. Best (1967) found both species regularly in the stomachs of sei whales shot by shore-based catchers within 200 nautical miles from Cape Town as far as 32°30′S; they appeared from September onward, taking the place of *Clausocalanus ingens*, which the whales had eaten earlier in the year in the same area. (Best's paper antedates the original descriptions of *Clausocalanus ingens* Frost & Fleminger, 1968, and *Calanoides macrocarinatus* Brodski, 1972; these two species are mentioned in the paper as *Clausocalanus arcuicornis*, forma *major* and *Calanoides carinatus*, respectively.)

At Tristan da Cunha, Wiborg (1964) found *Calanus tonsus* in large numbers at the surface between 15 December and 2 February, but absent later in February and in March.

The record of *Calanus tonsus* in a single sample south-west of Madagascar (WS 50, September 1968) may appear suspect, considering the low latitude, 28°S; however, De Decker & Mombeck (1964) recorded a similar isolated occurrence of *C. tonsus* at a station only 60 nautical miles further north in a vertical net haul between 50 m and the surface, during the IIOE cruise in June 1961.

The occurrence pattern of *Calanus tonsus* and *Calanoides macrocarinatus* in the present material and their near-simultaneous seasonal appearance at the surface in large numbers far north of the Subtropical Convergence are another indication of a substantial intrusion of southern elements on to the South African shelf, apparently without relation other than vicinity to the inshore upwelling of the Benguela Current System.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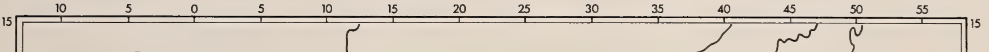
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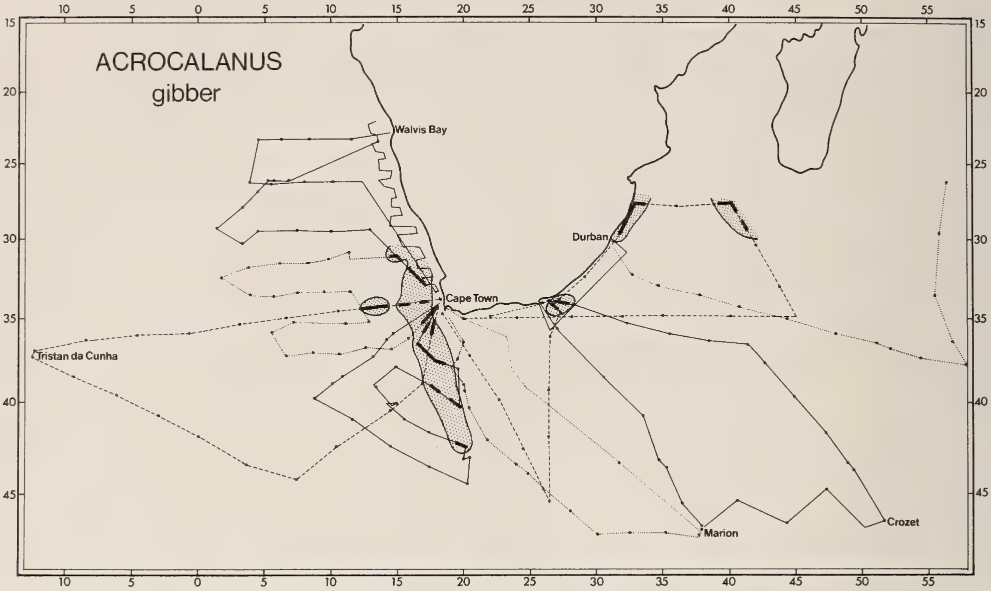
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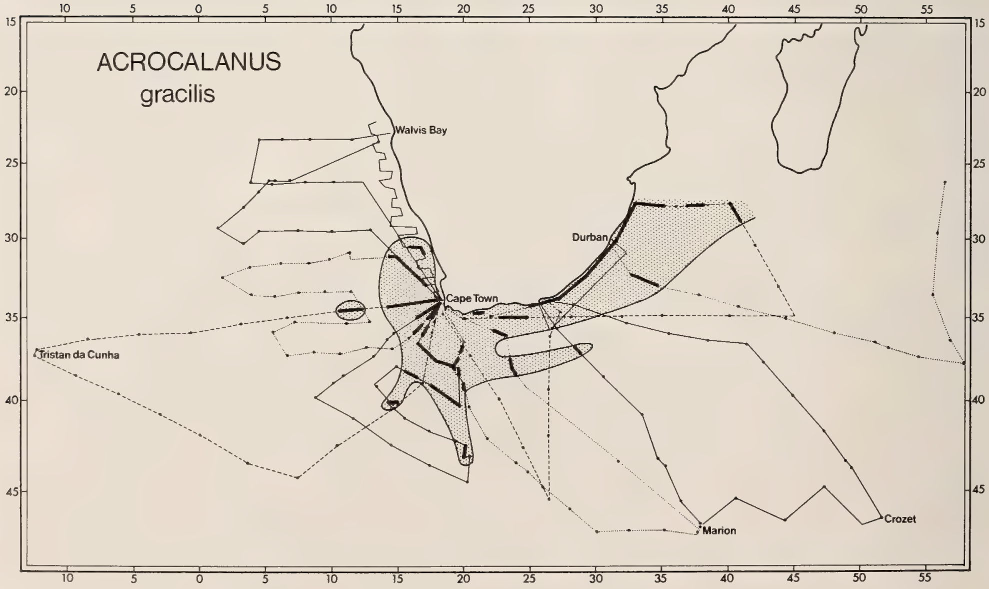
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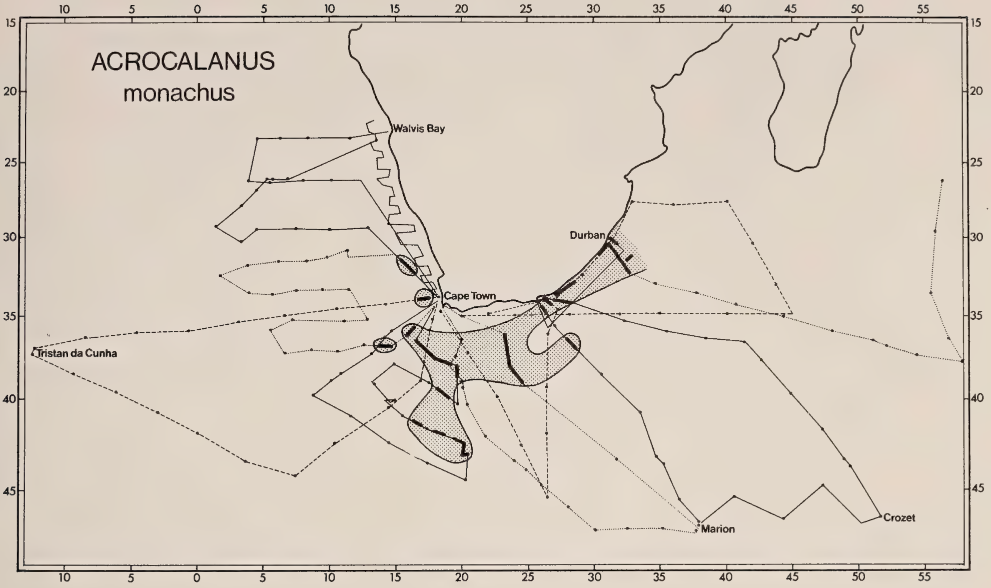
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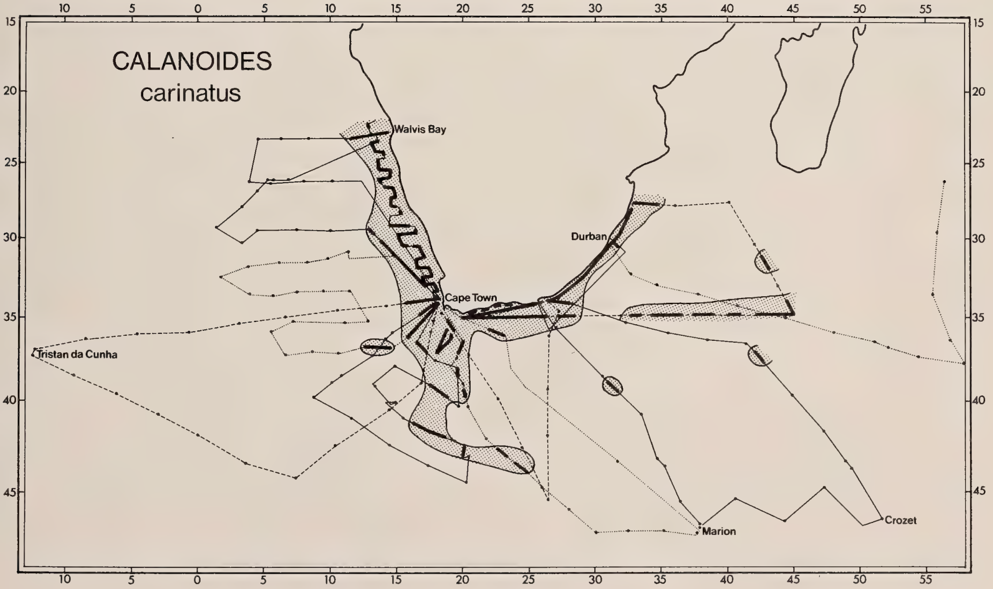
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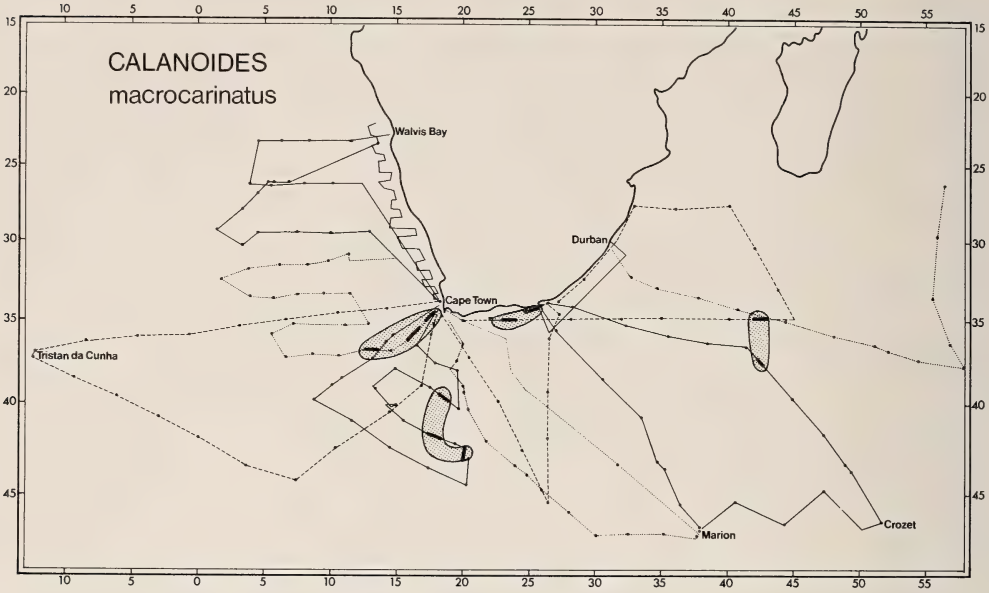
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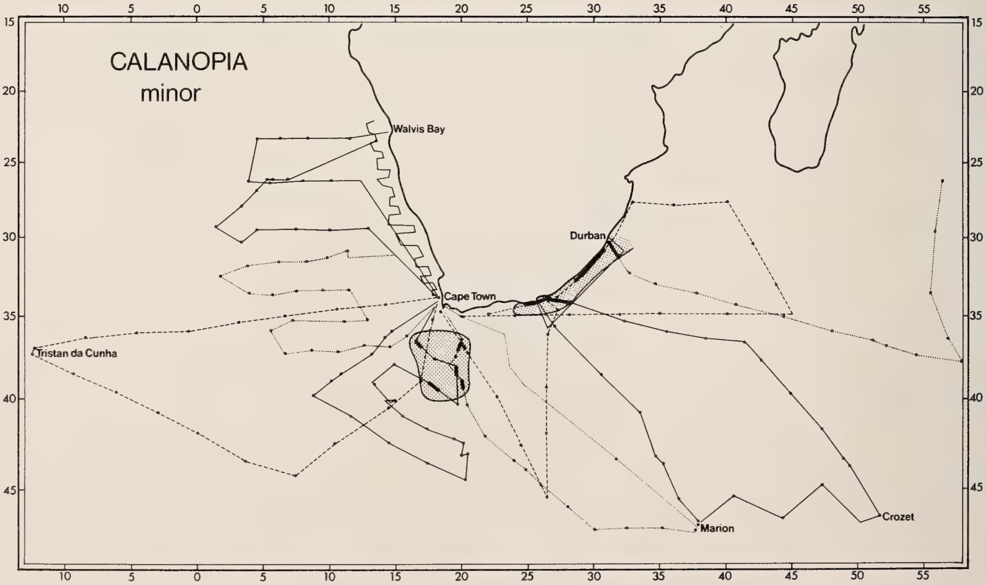
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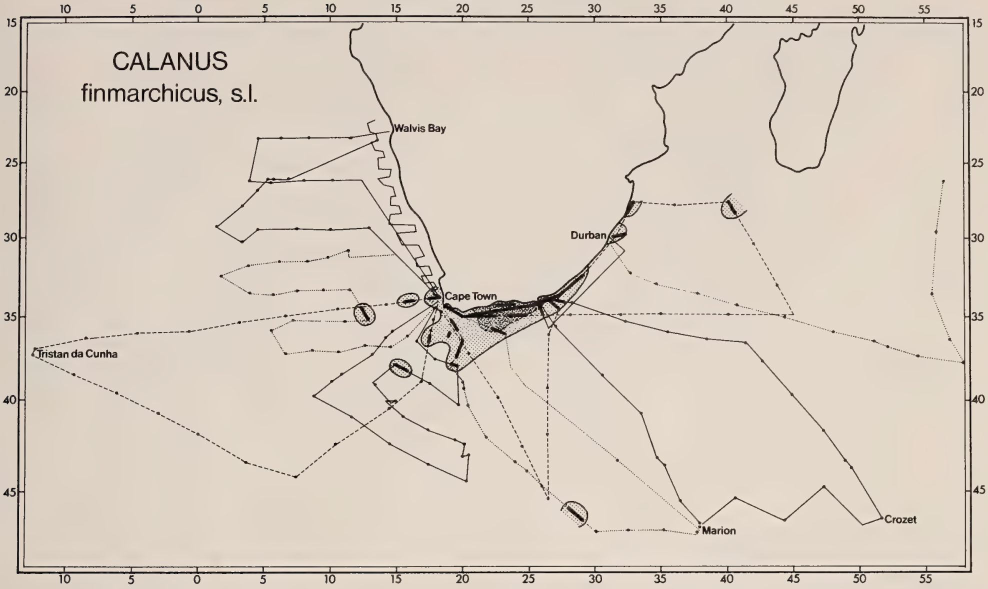
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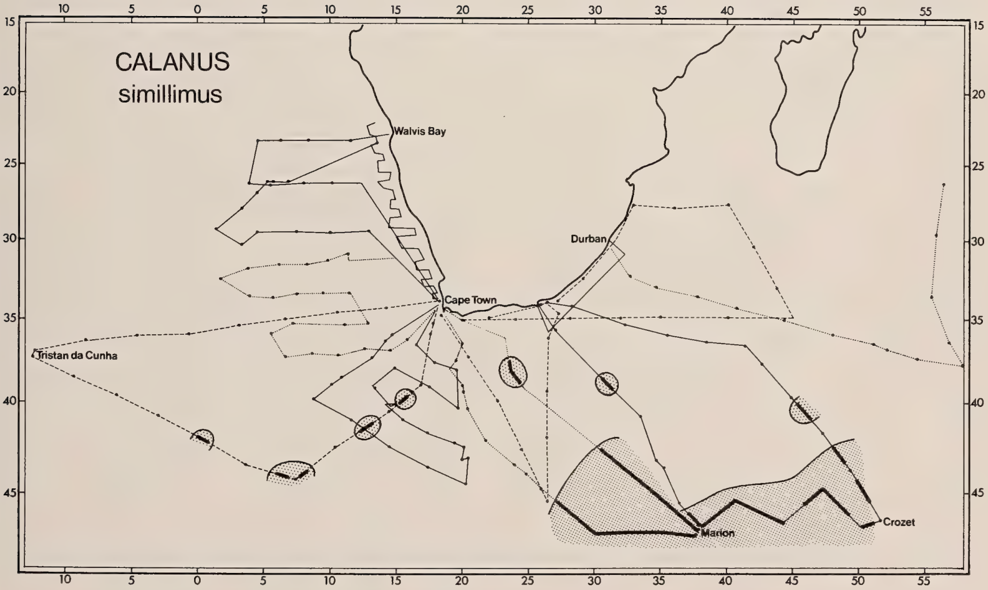
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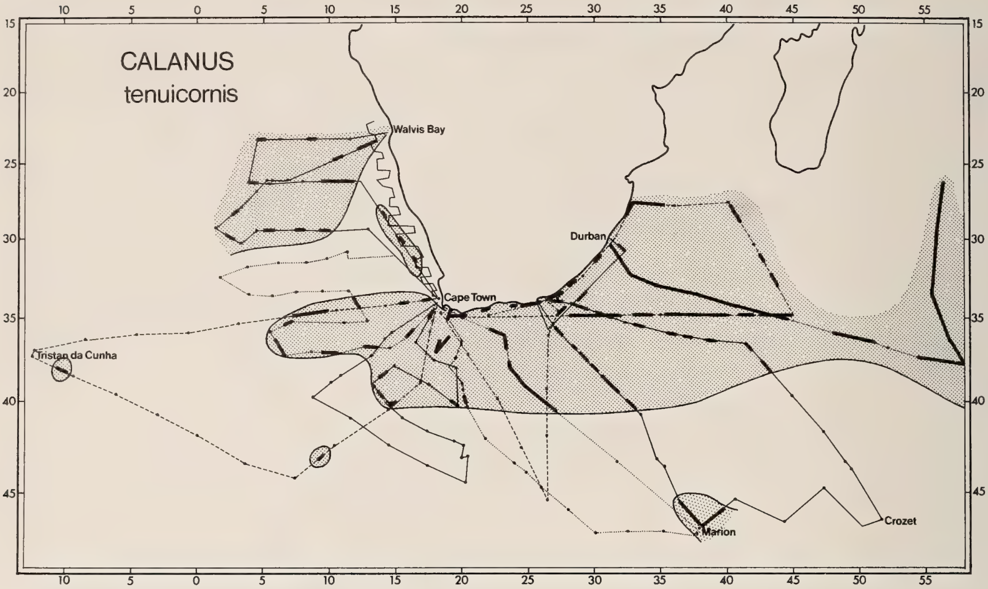
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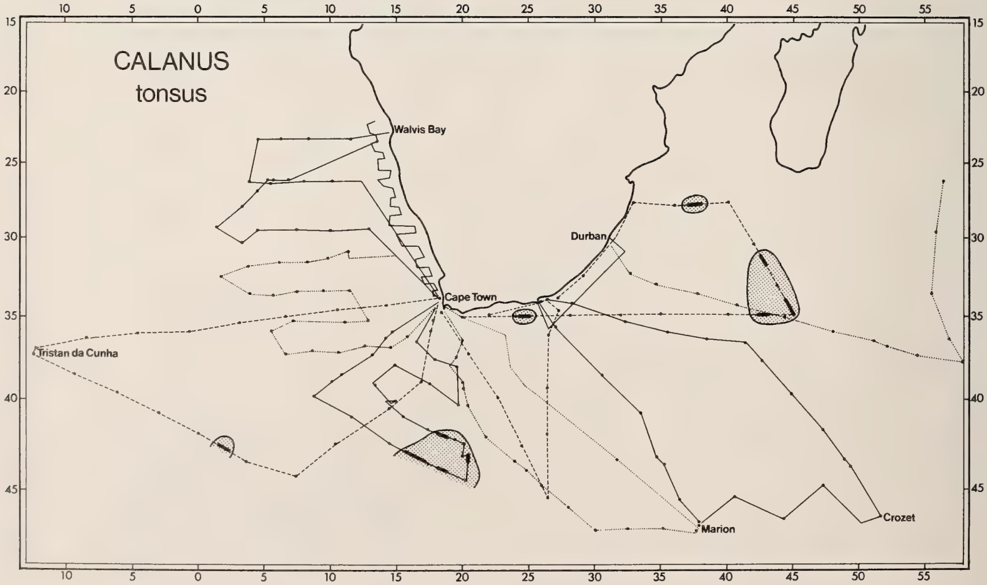
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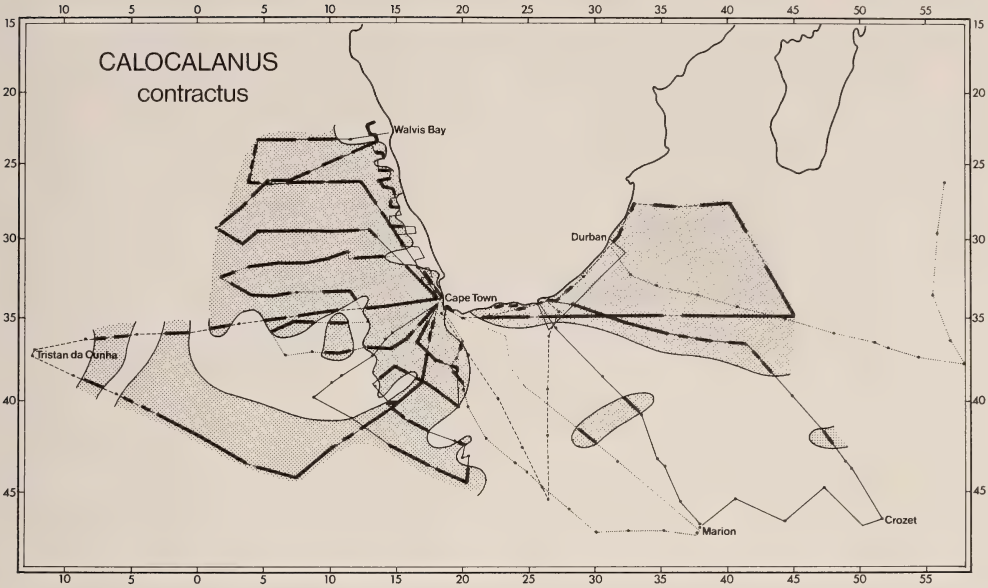
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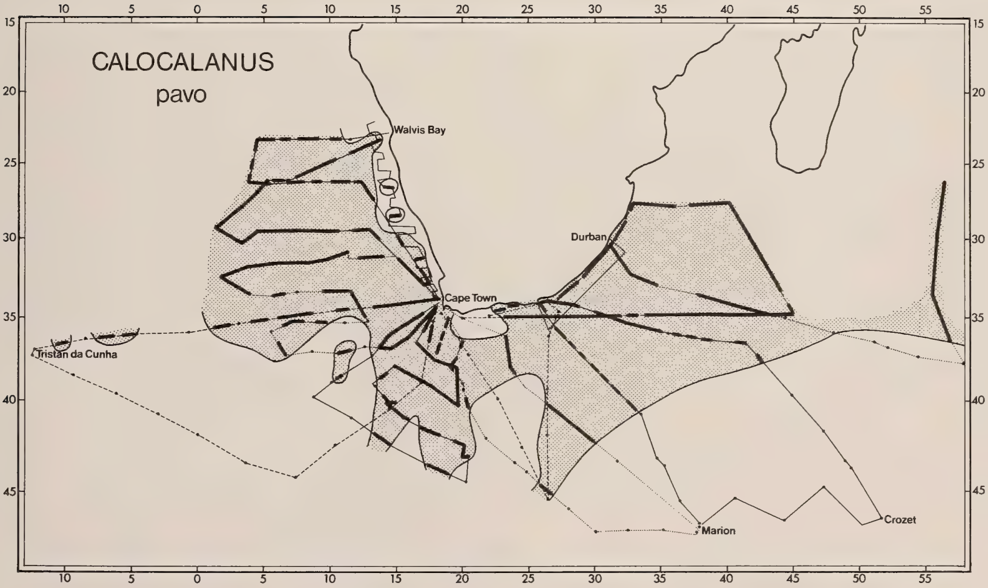
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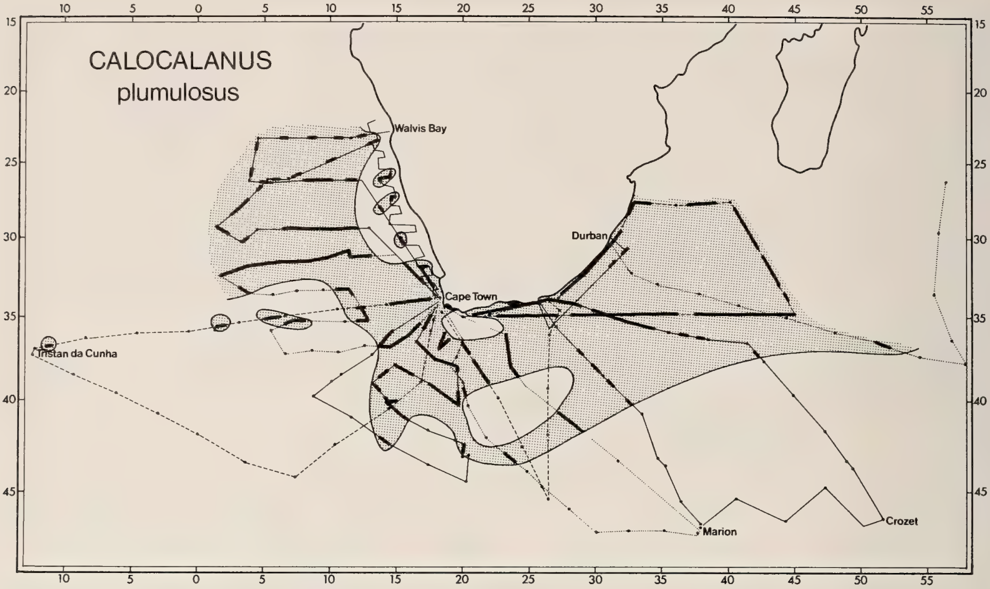
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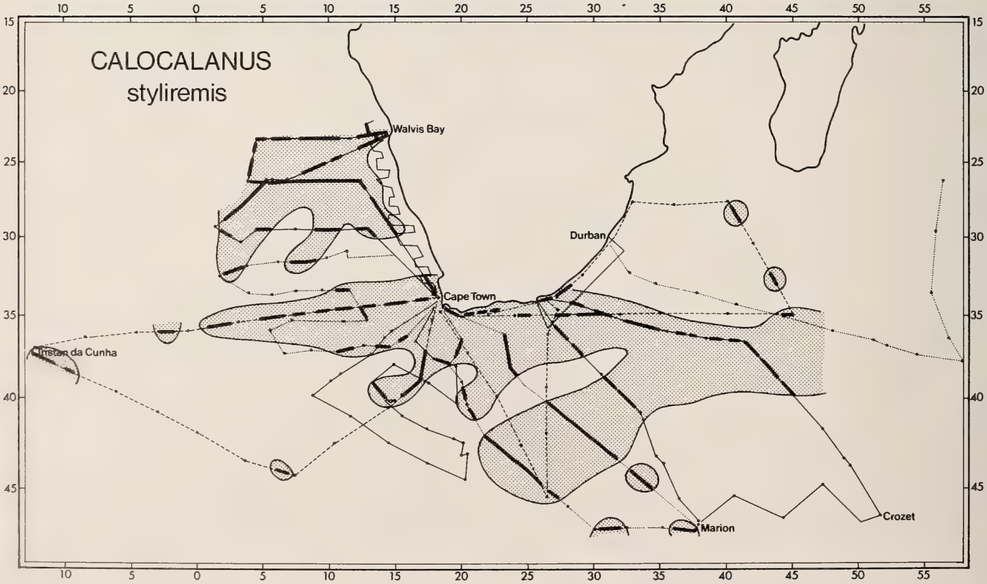
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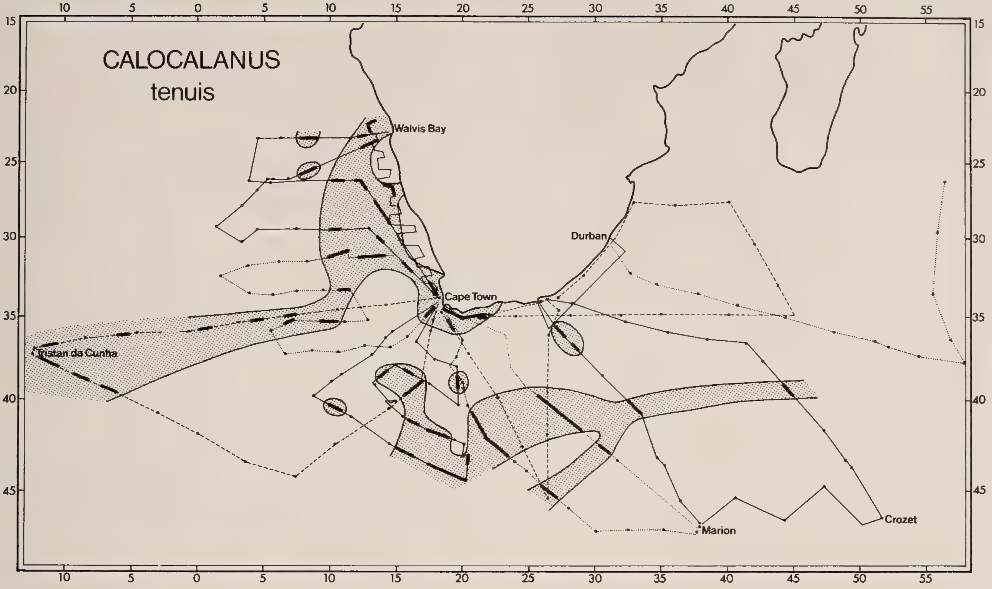
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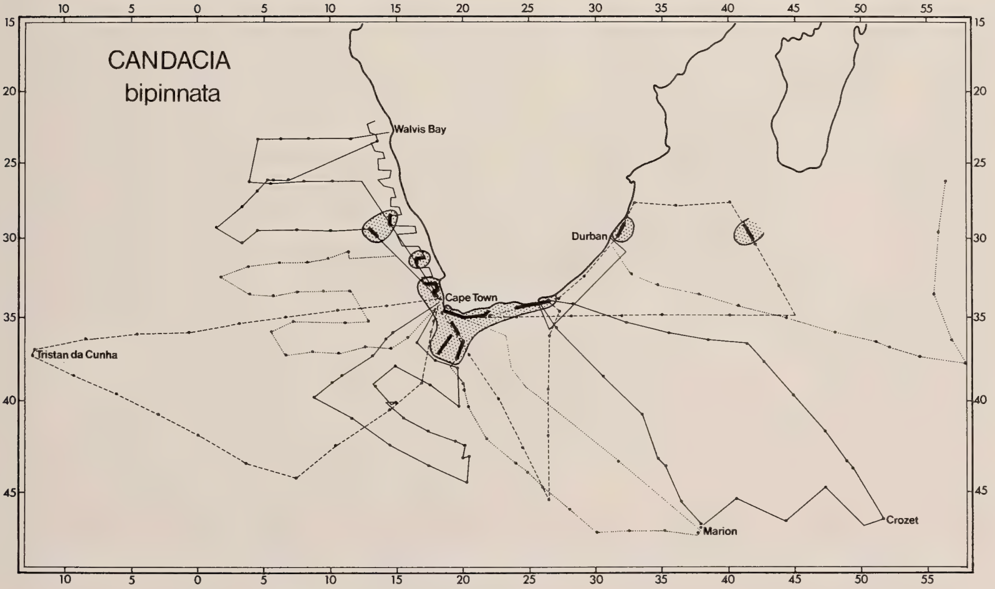
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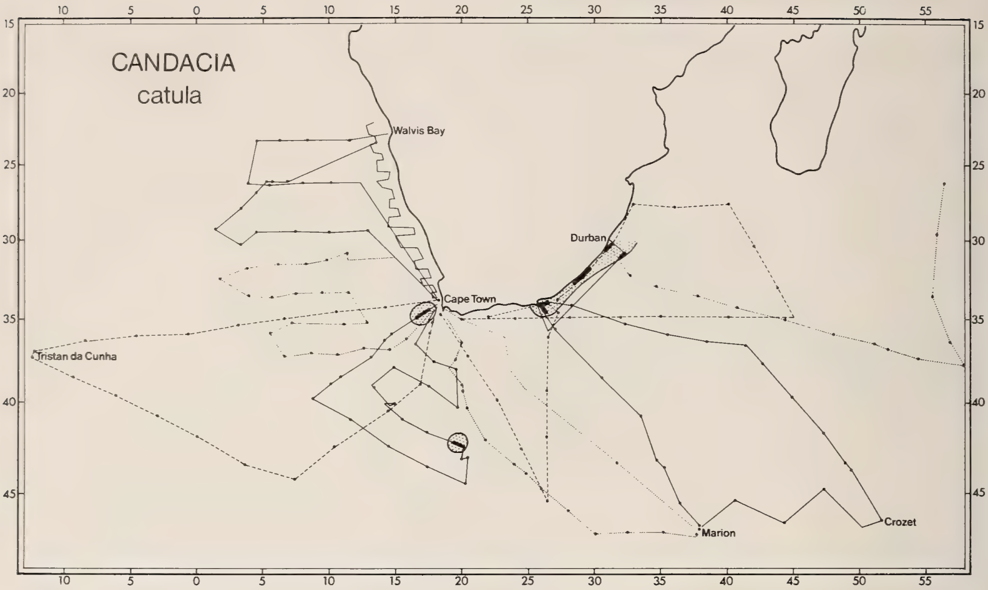
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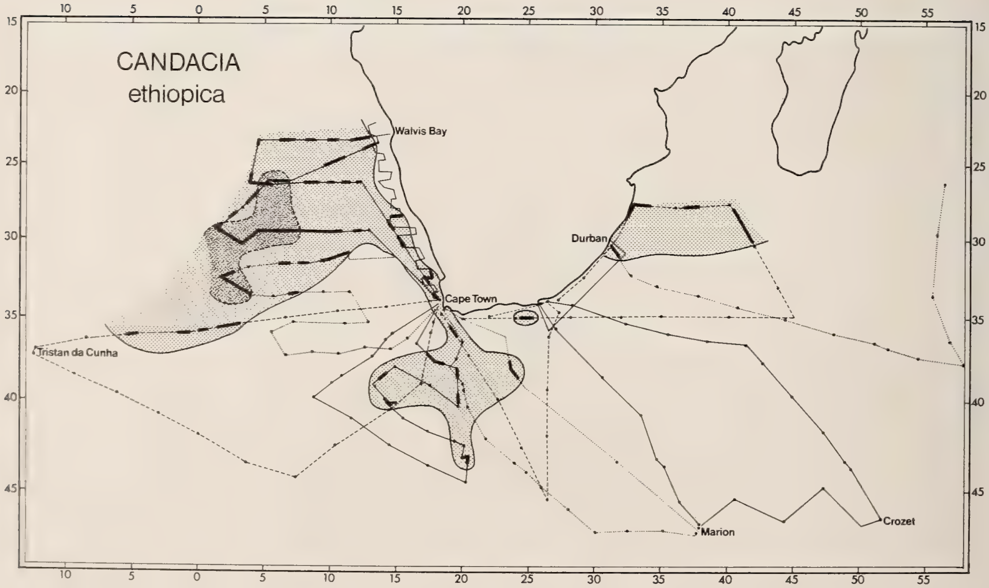
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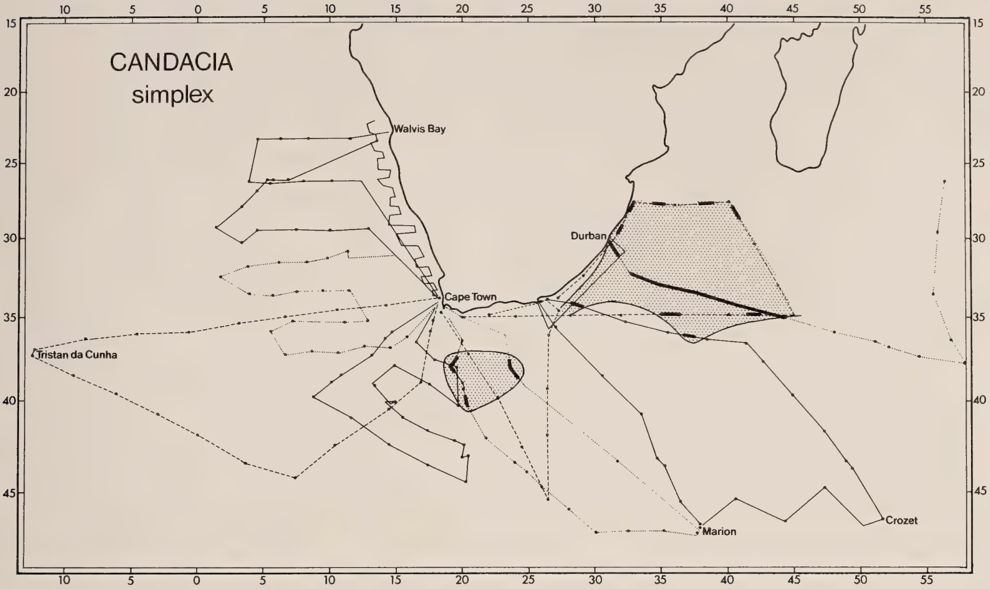
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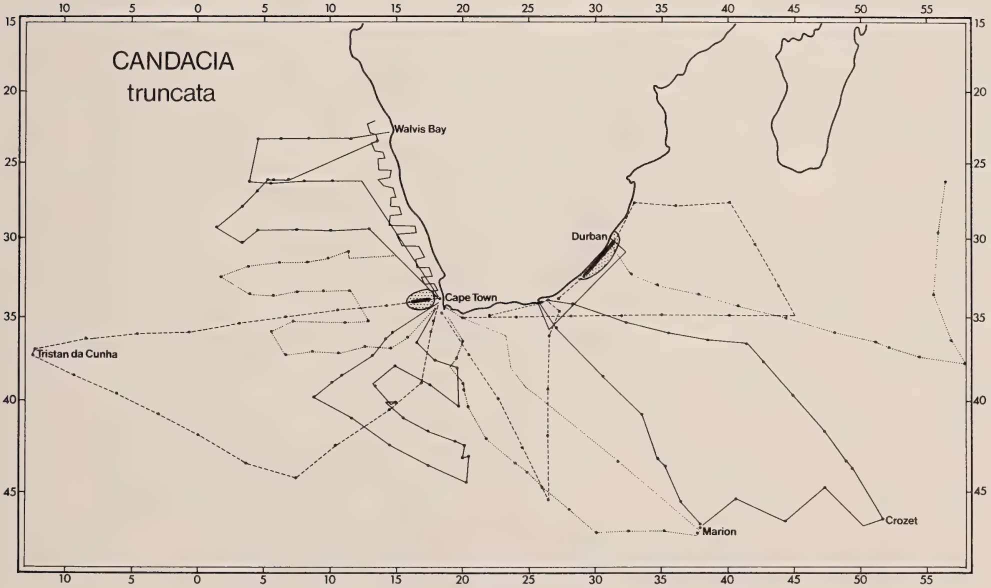
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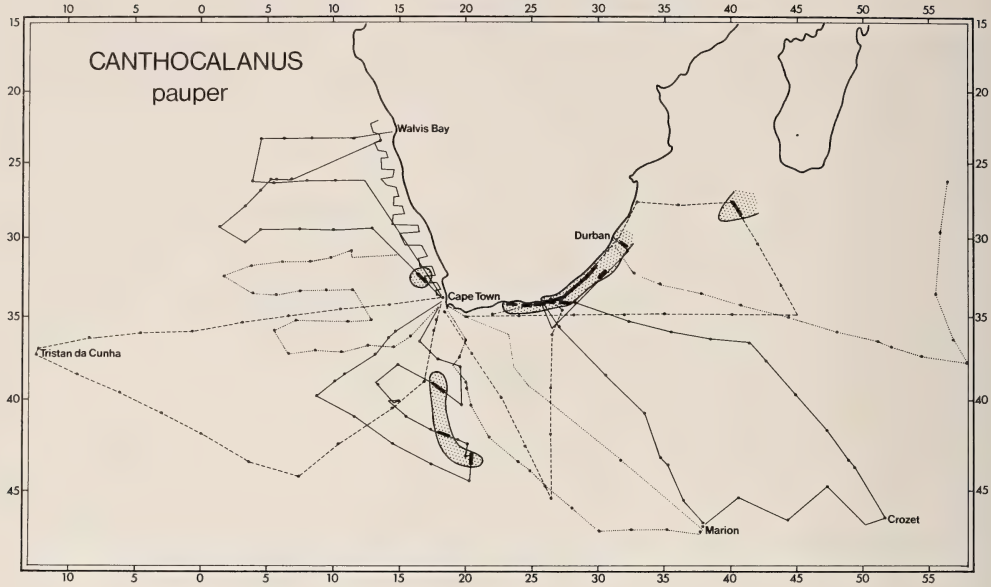
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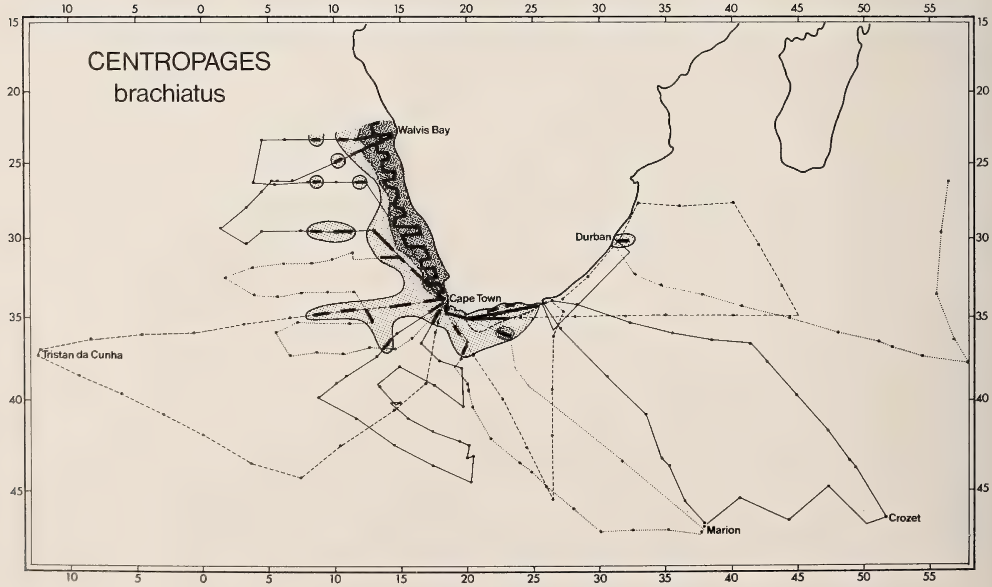
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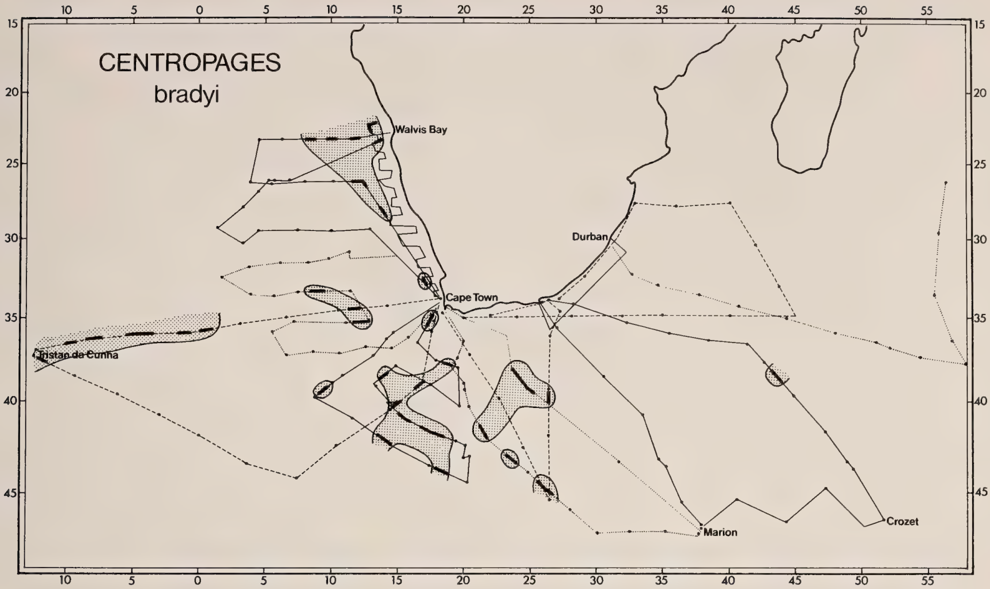
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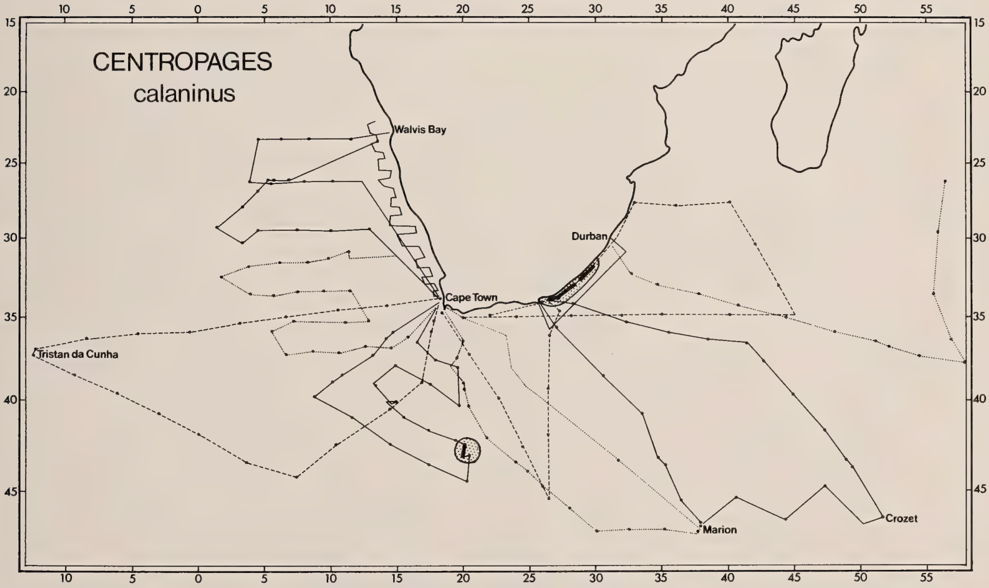
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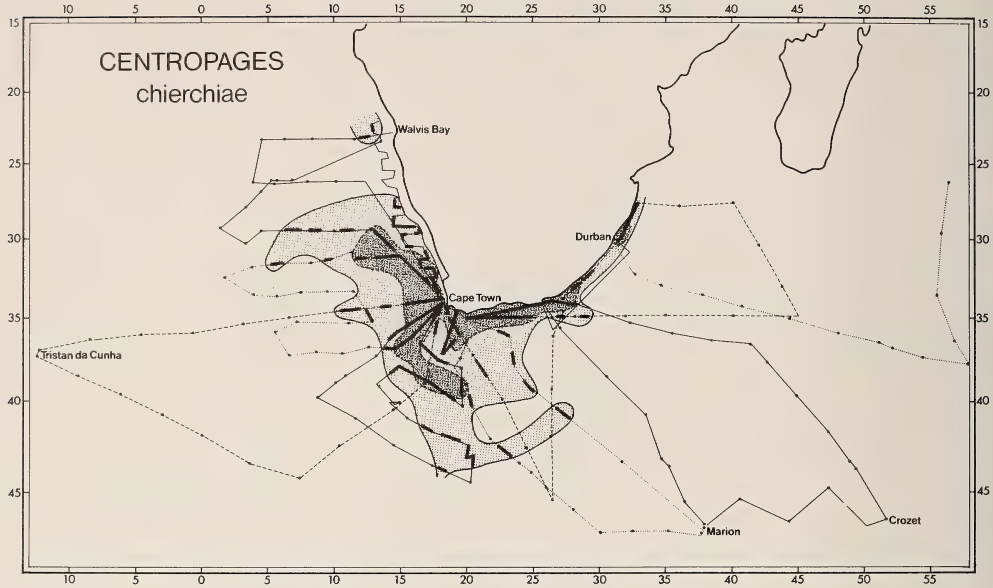
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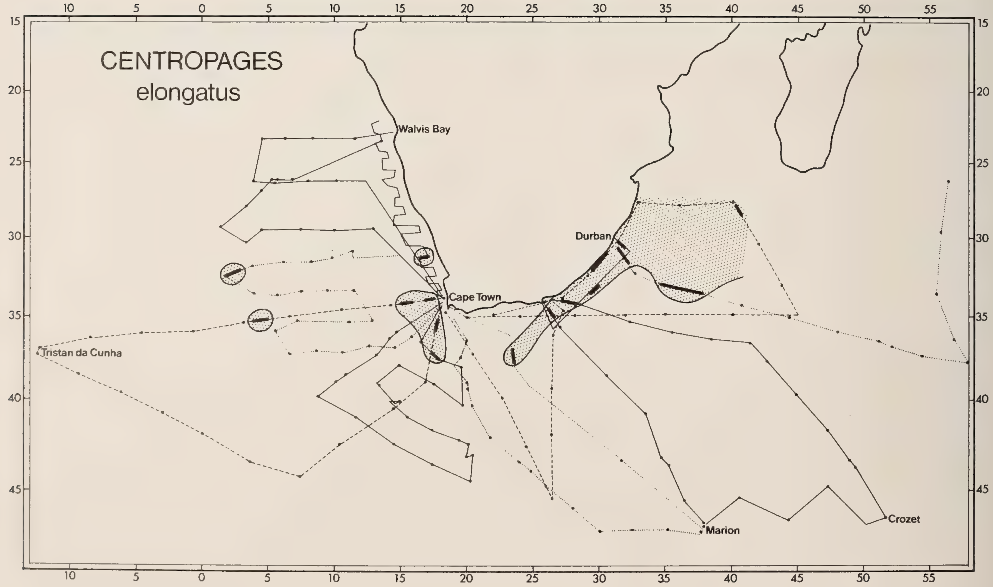
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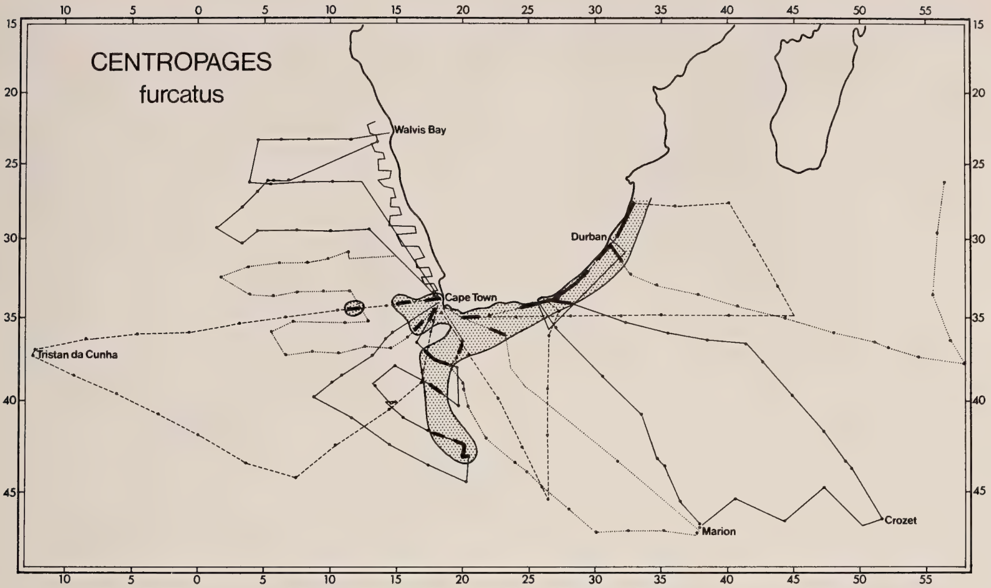
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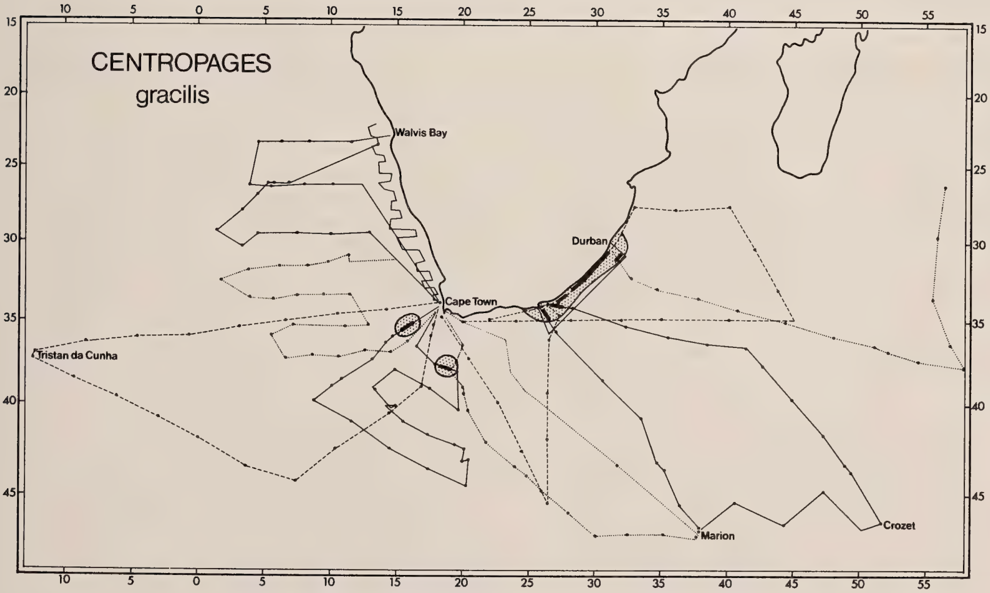
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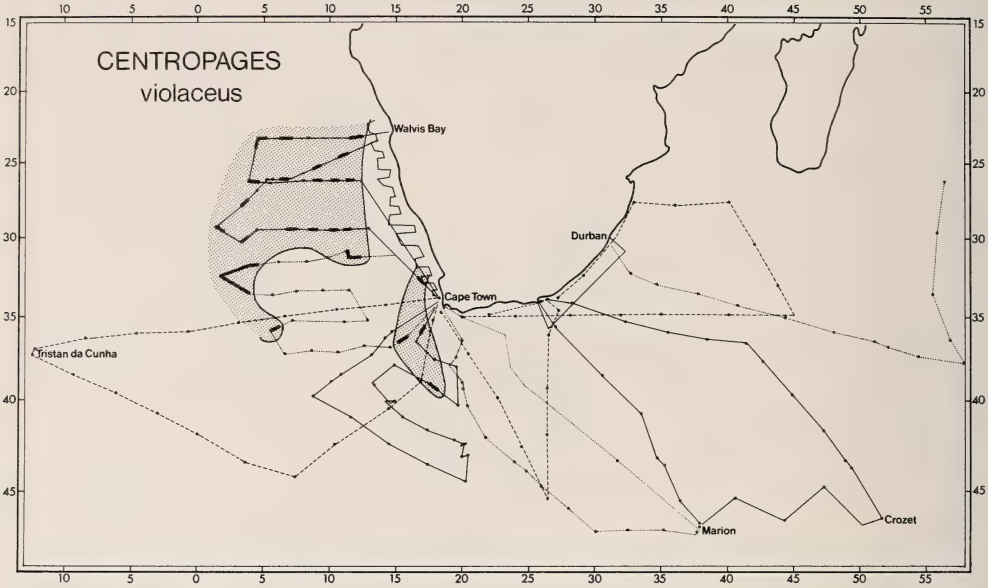
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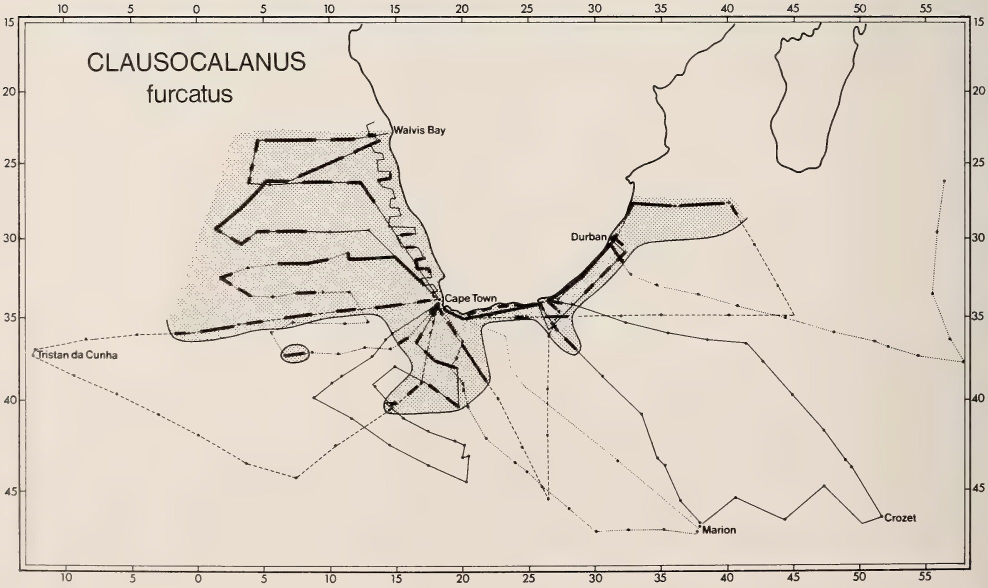
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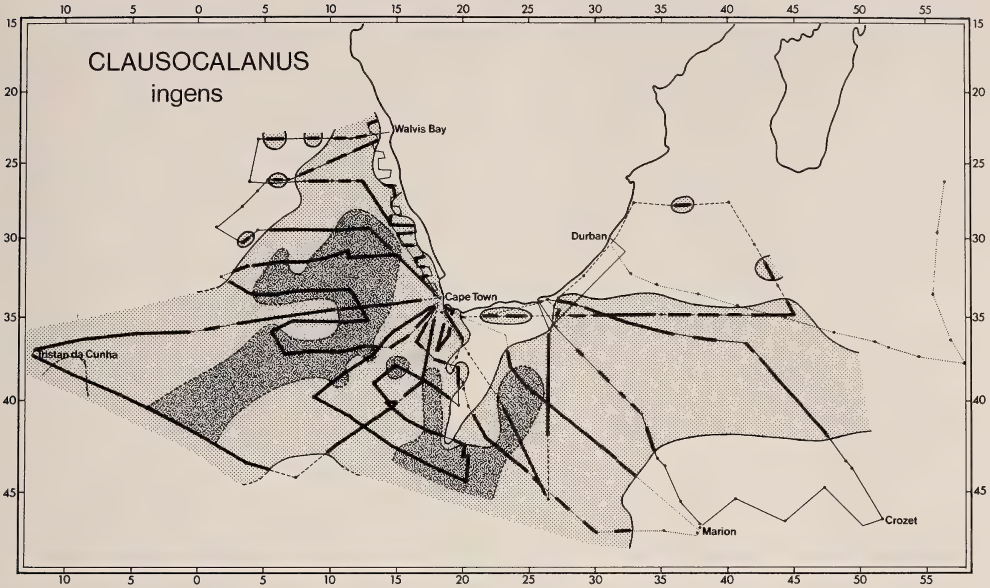
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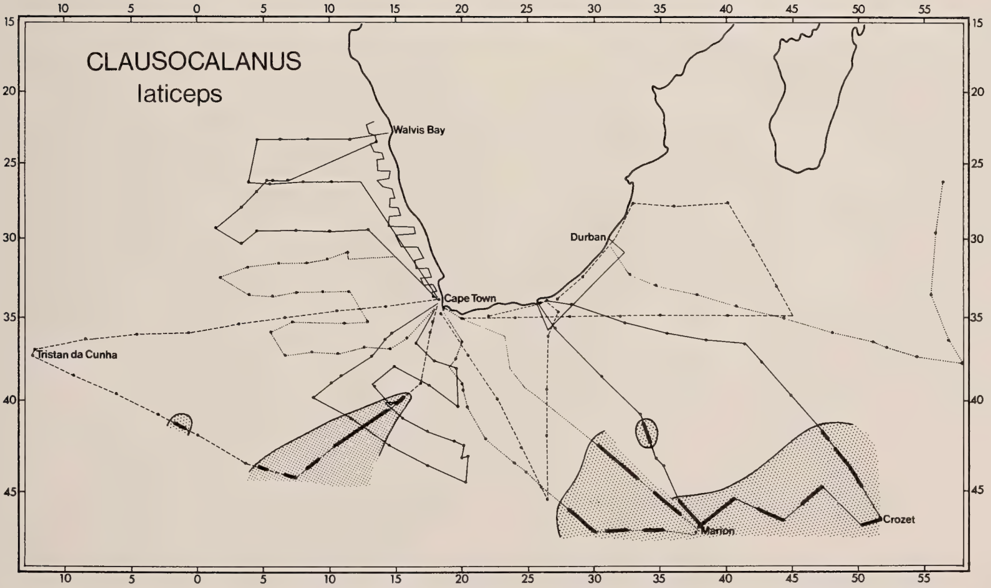
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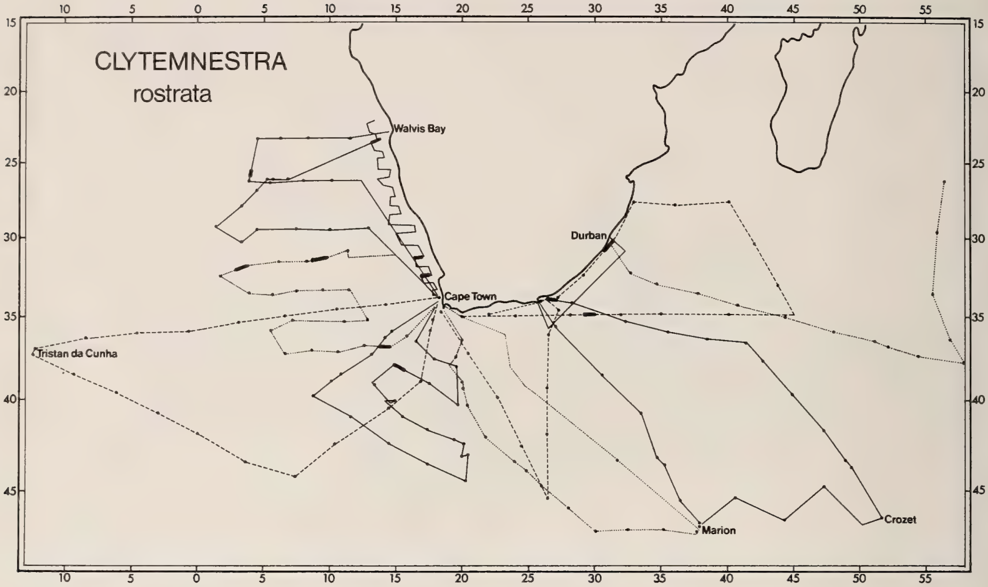
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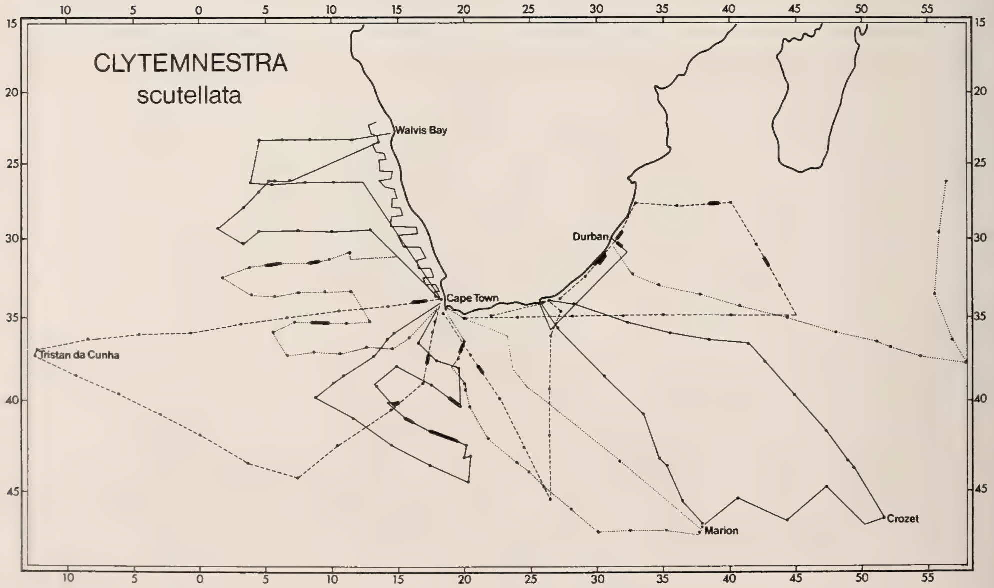
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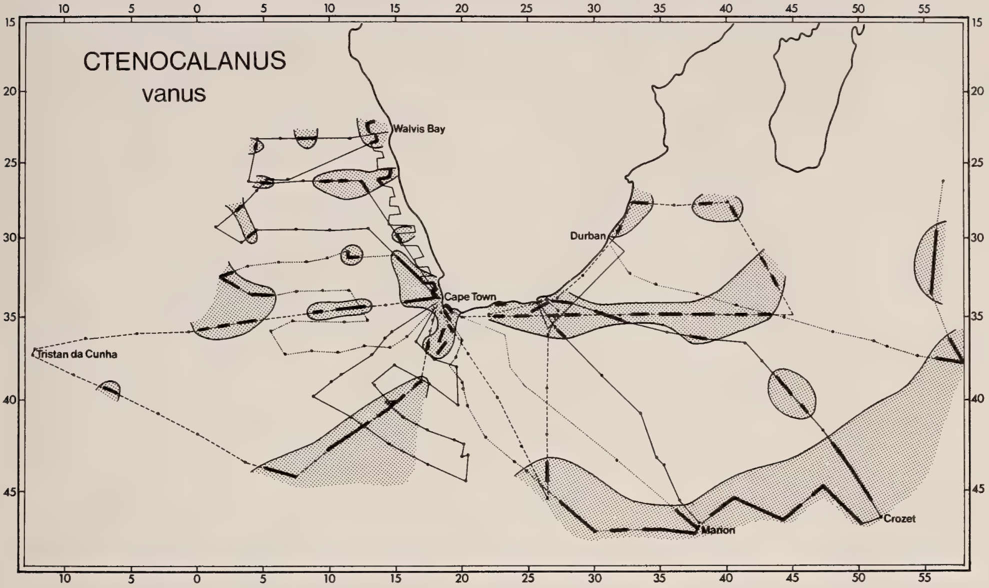
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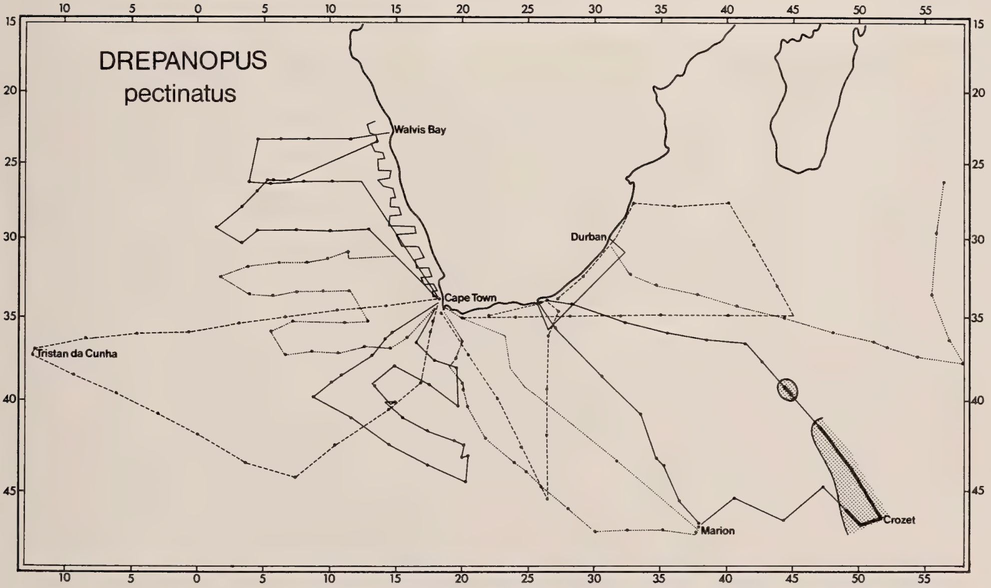
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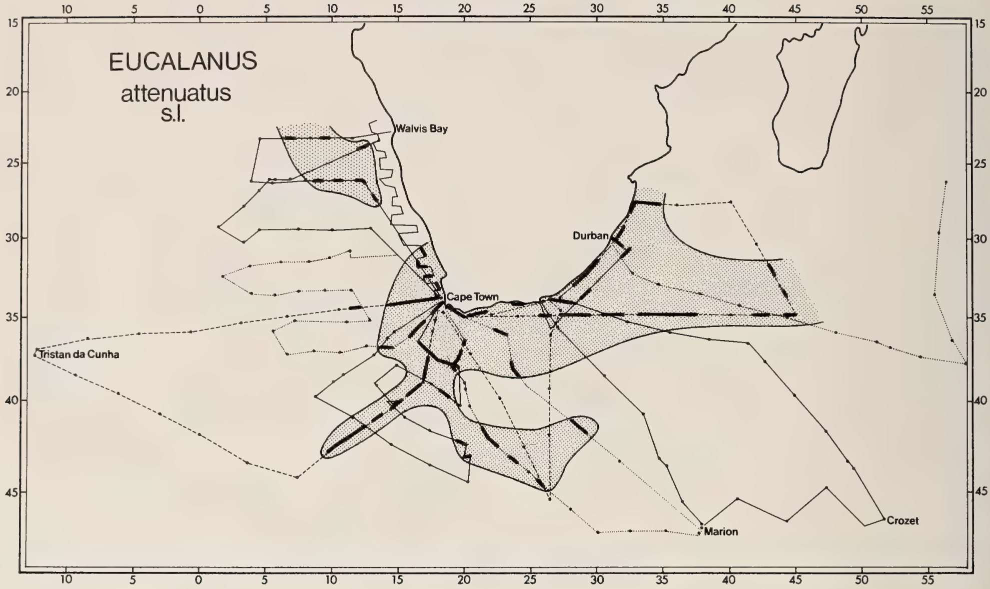
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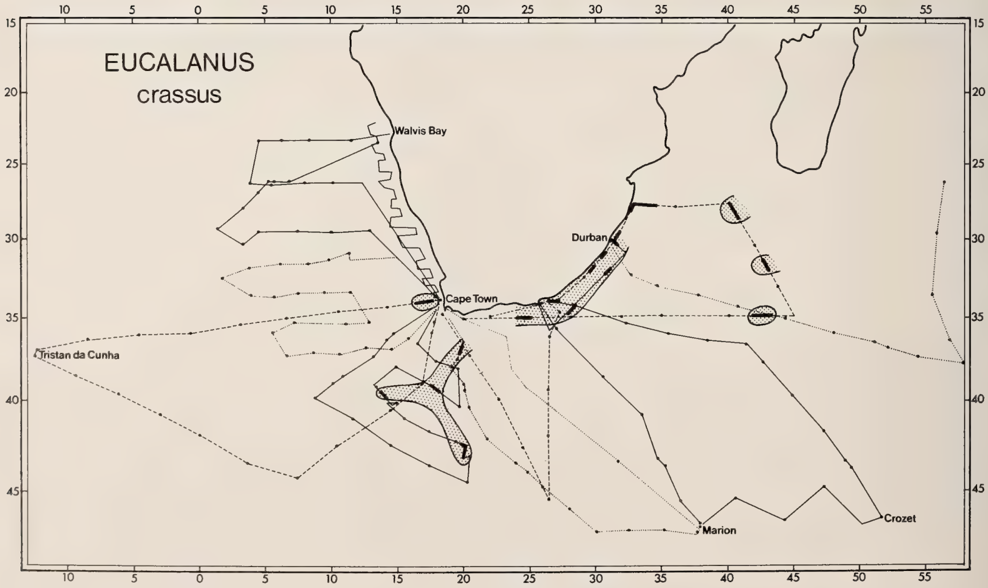
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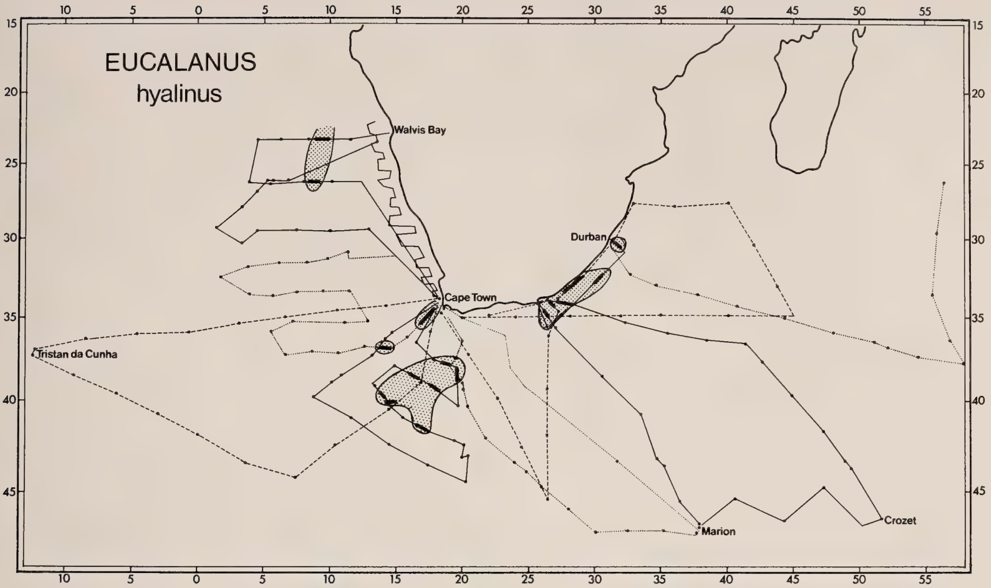
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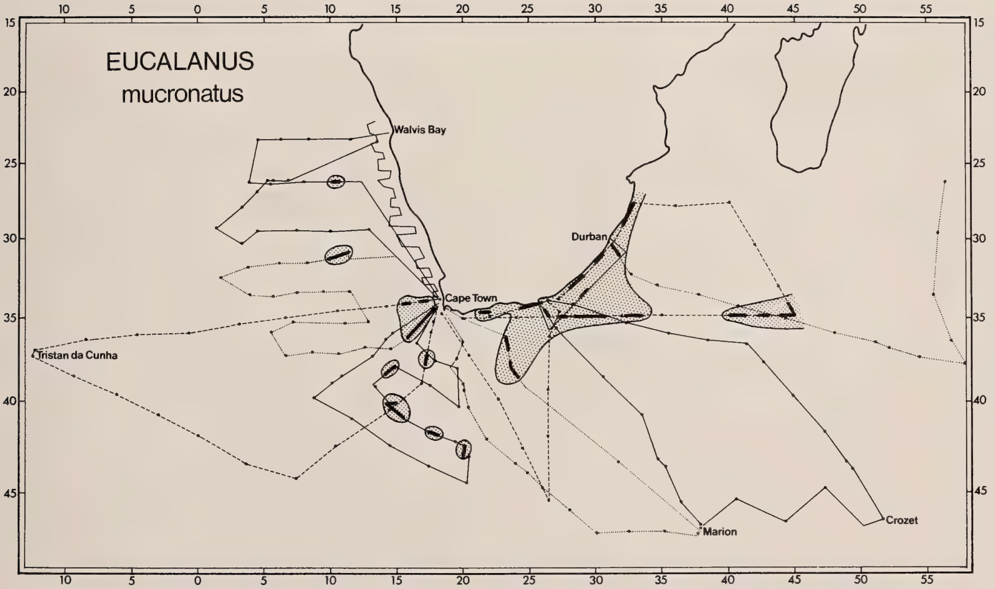
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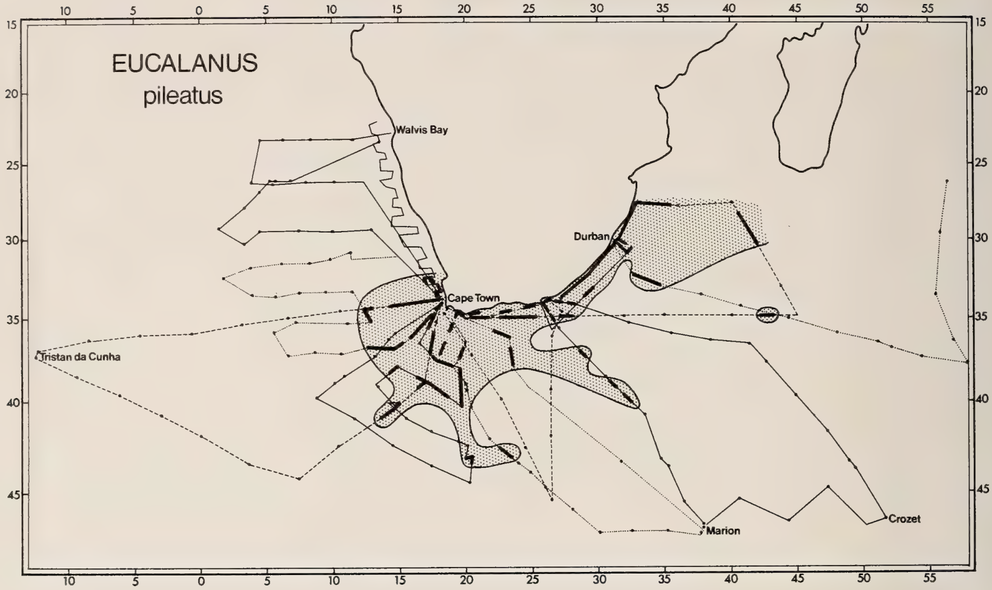
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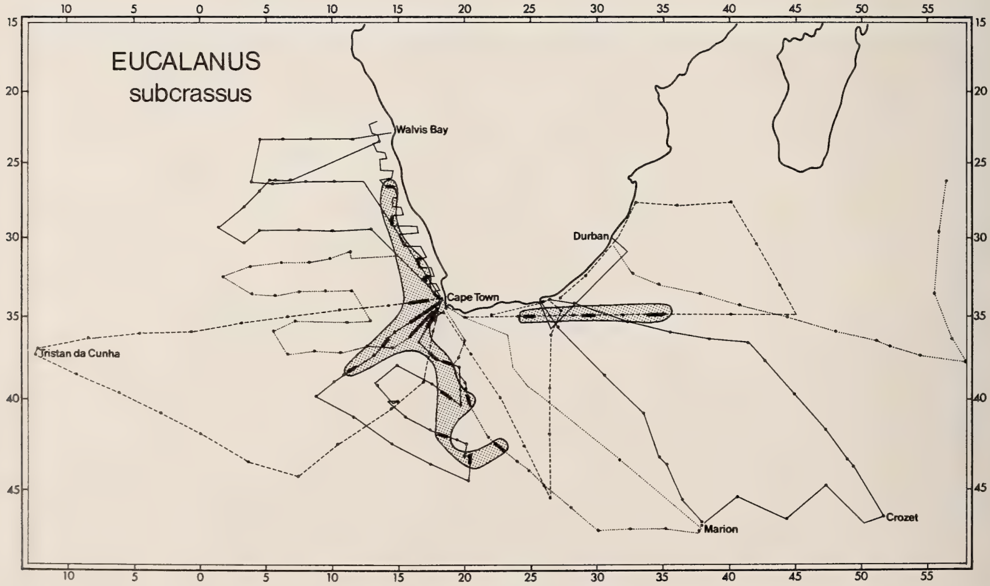
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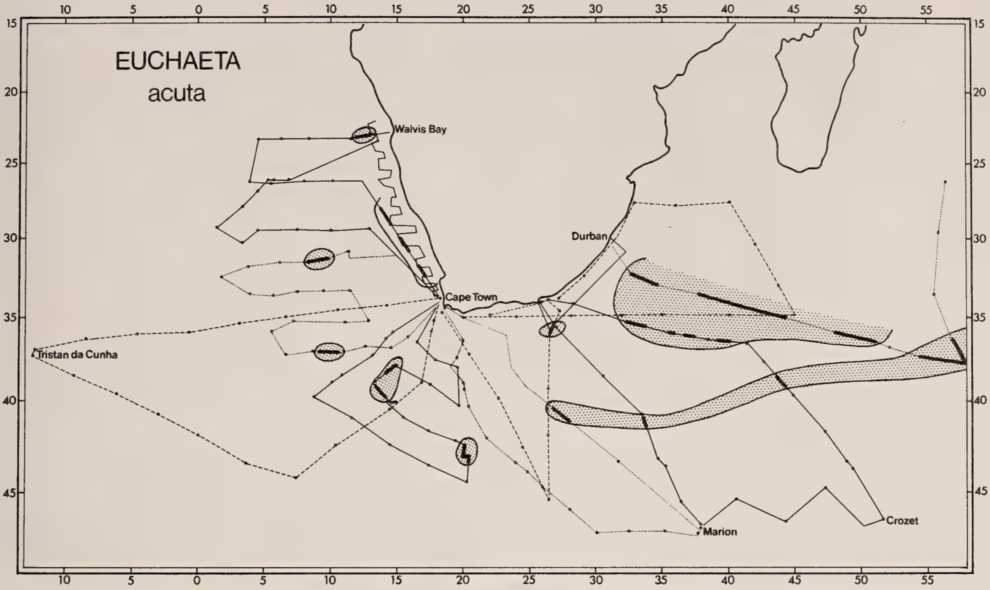
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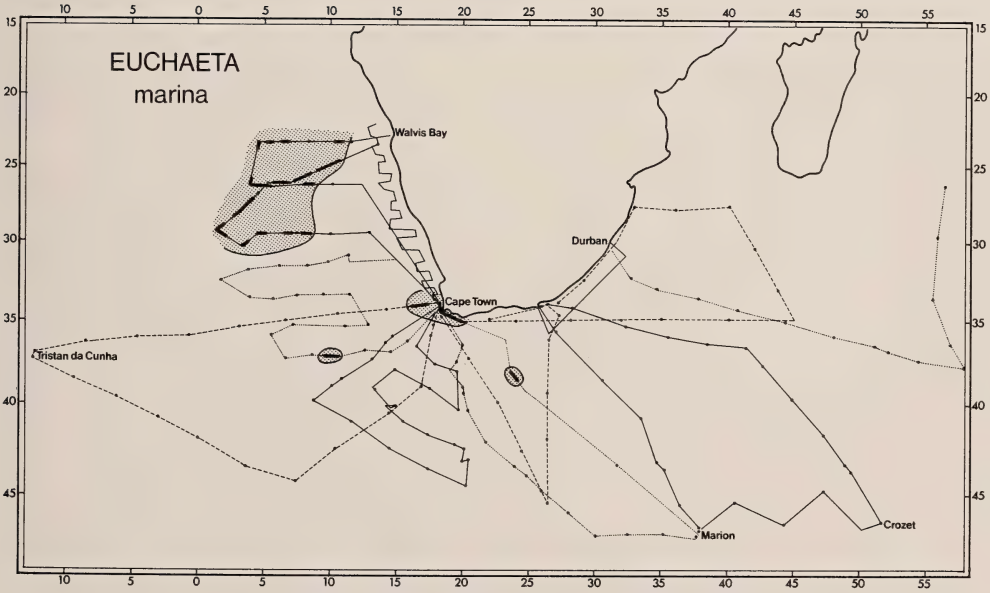
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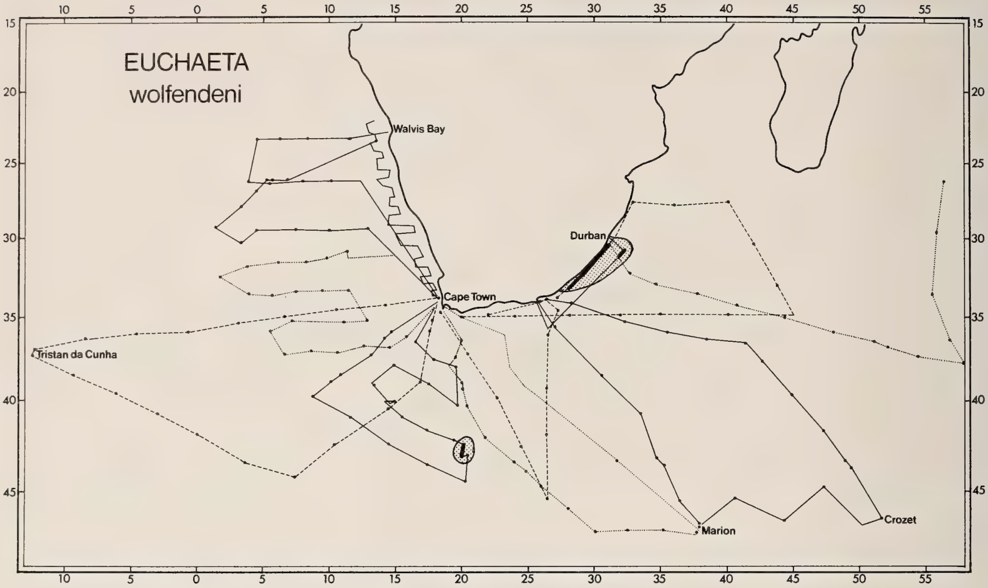
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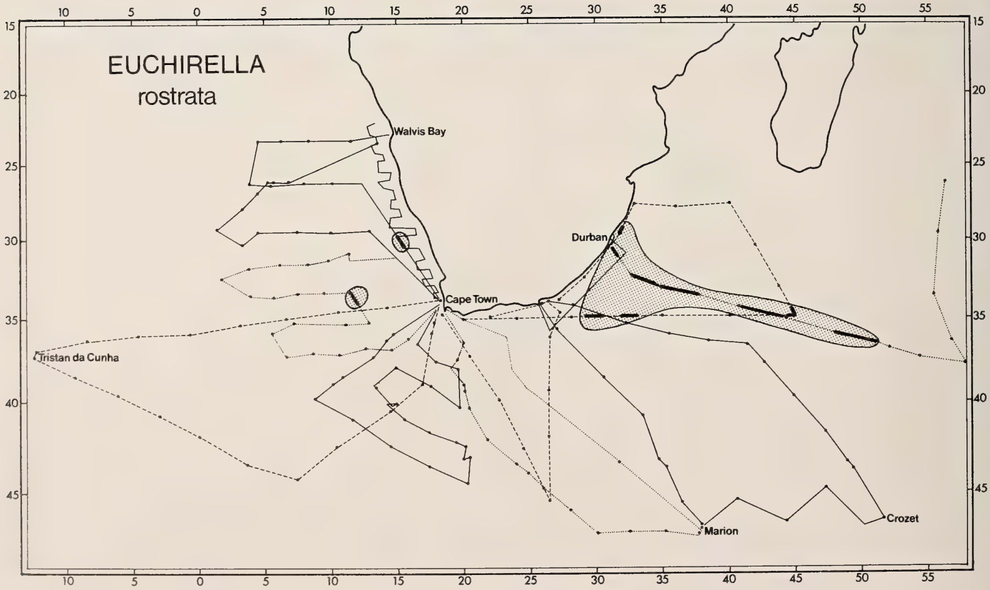
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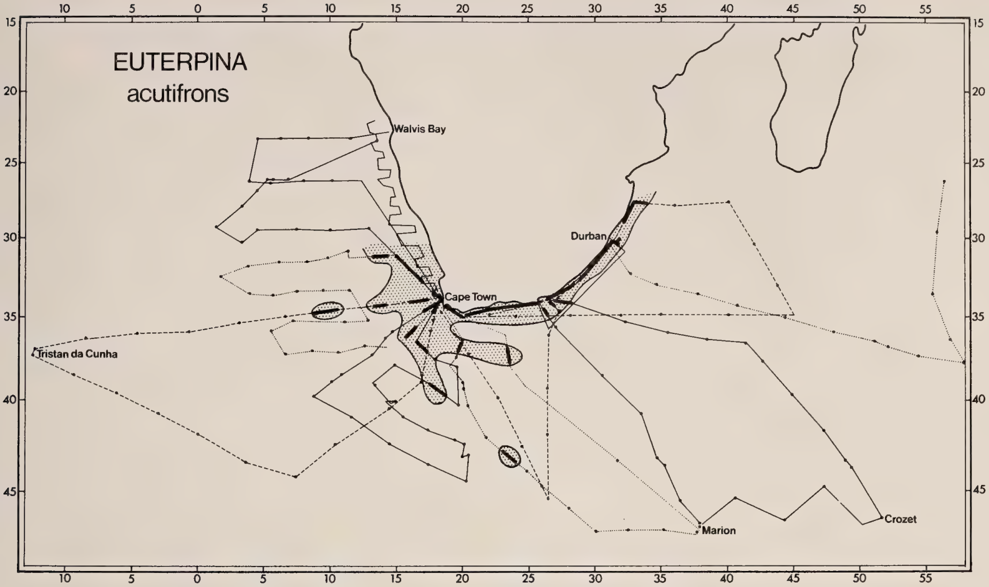
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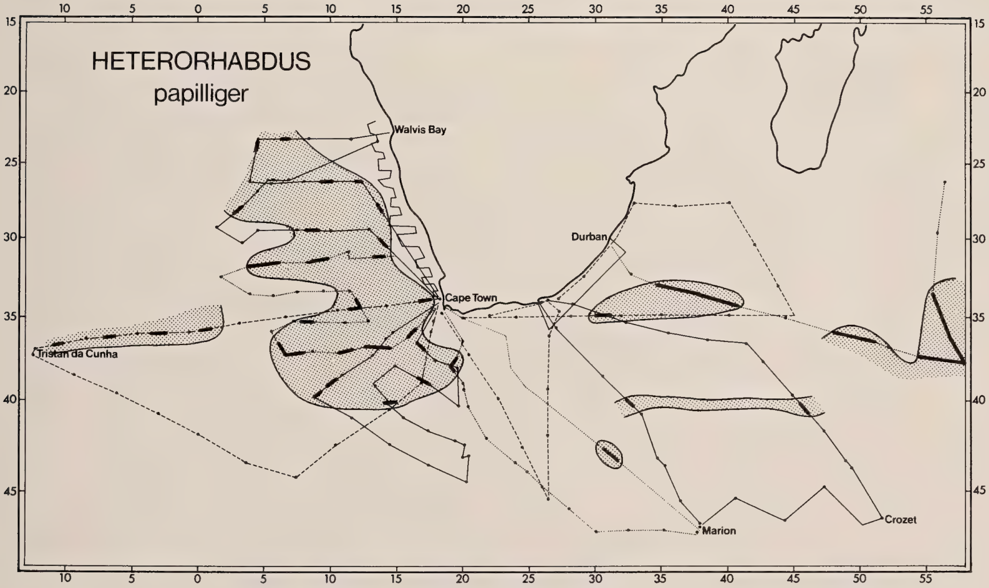
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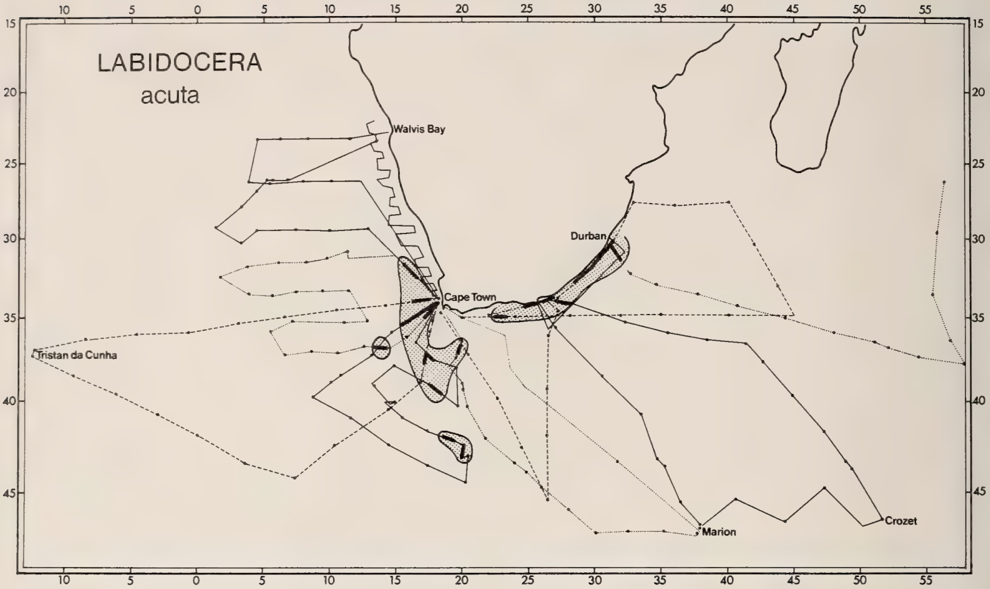
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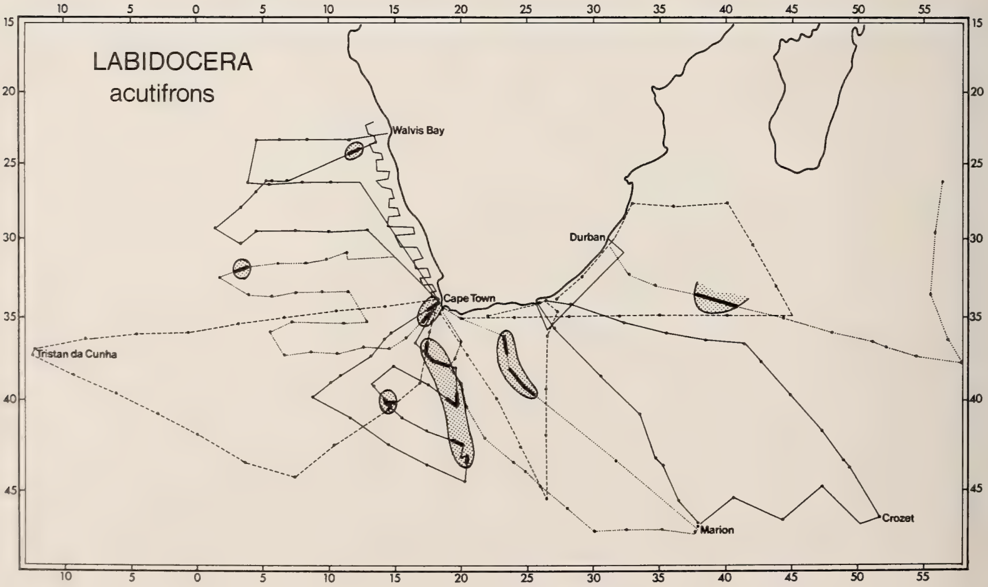
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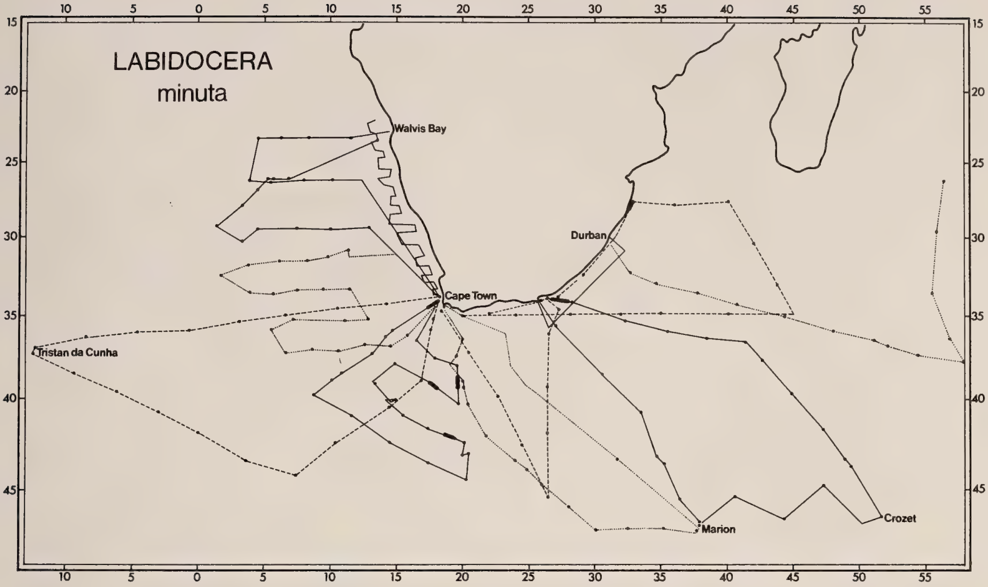
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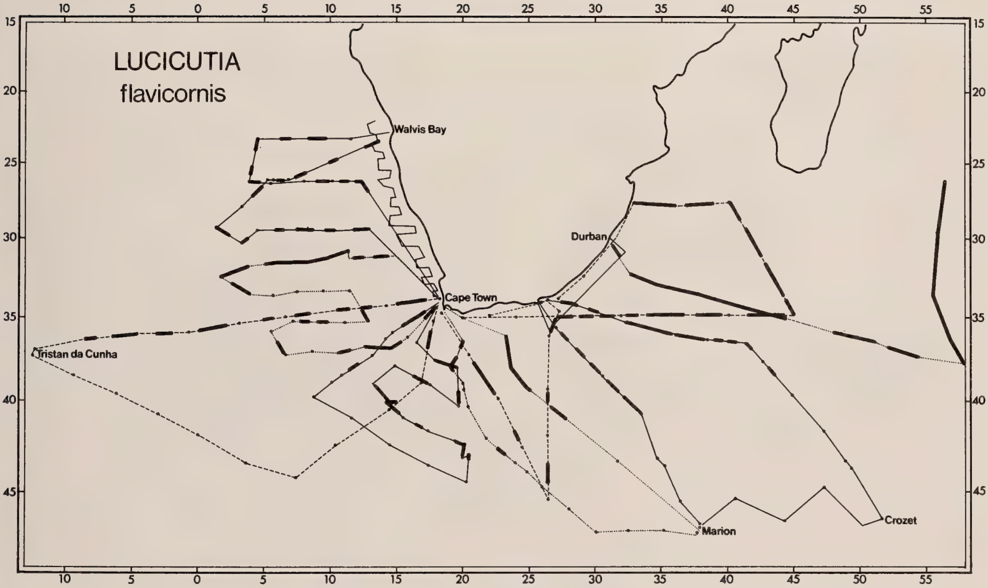
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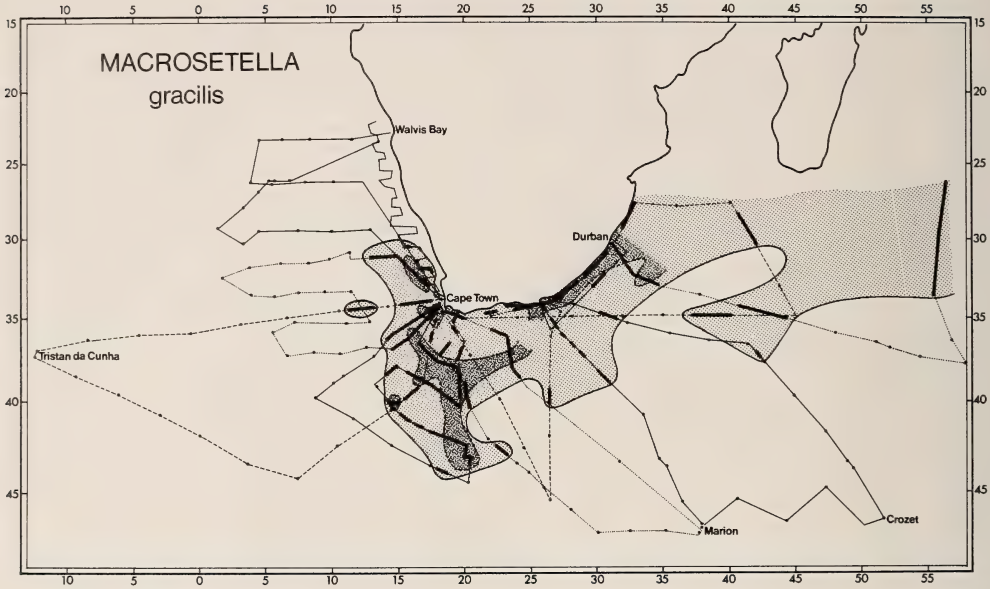
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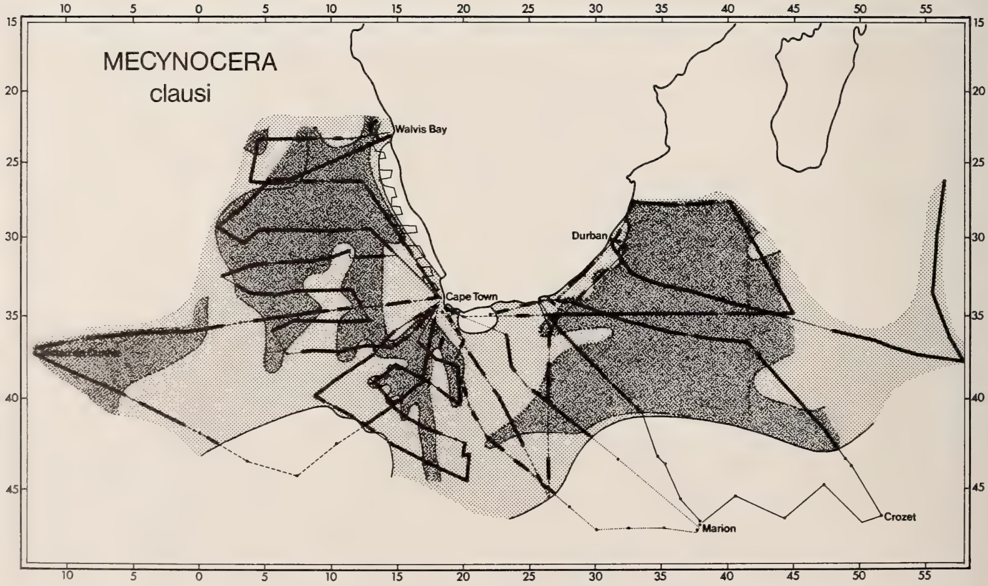
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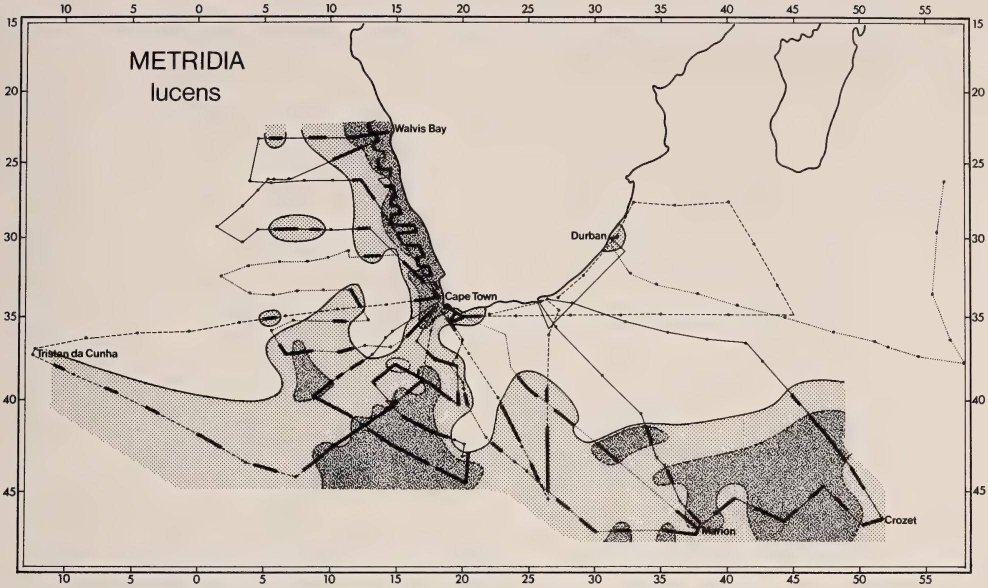
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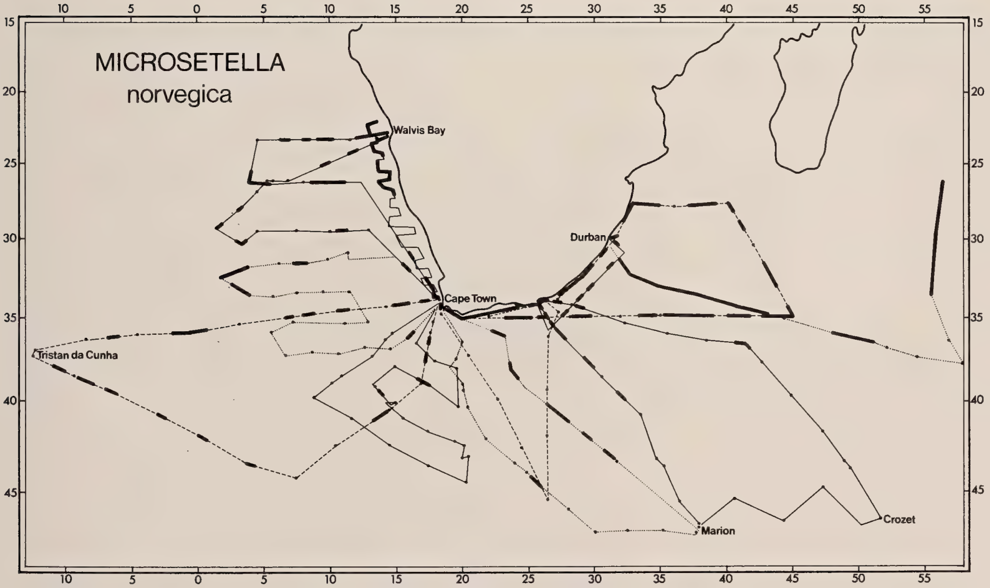
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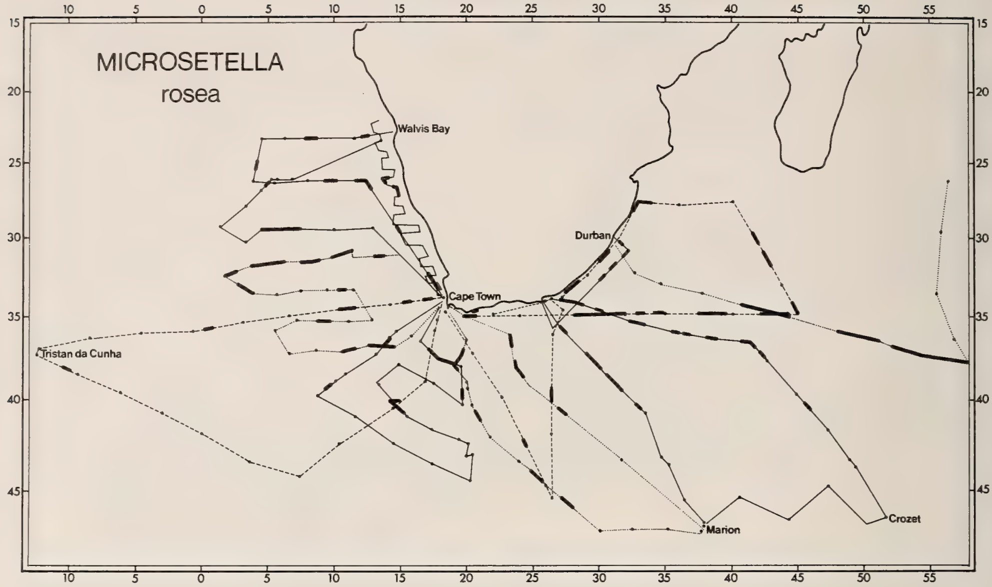
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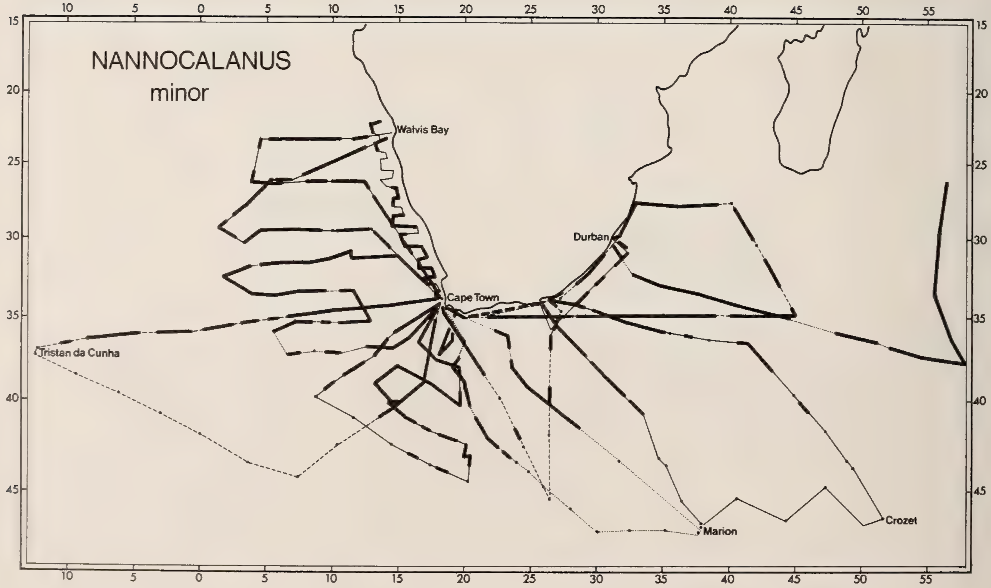
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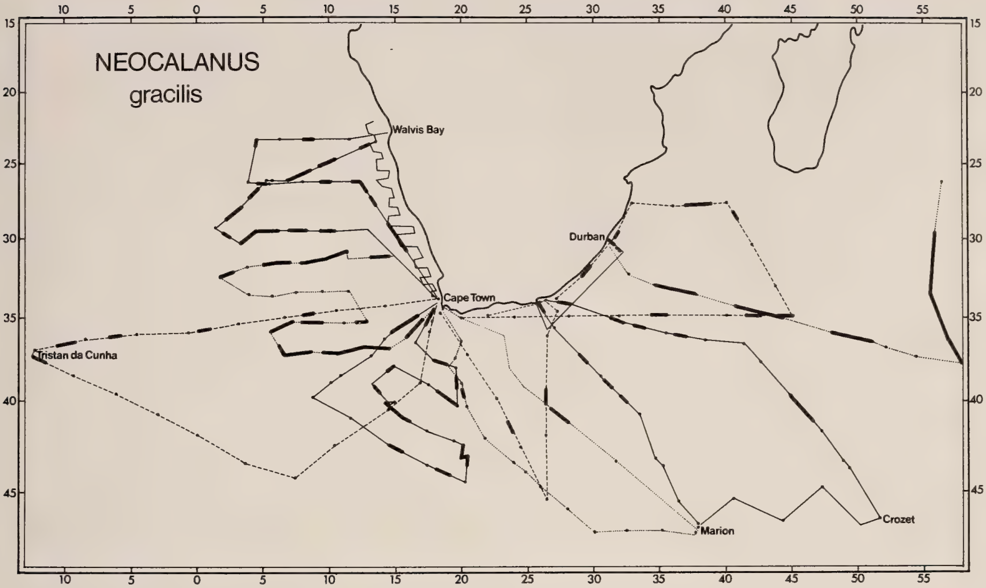
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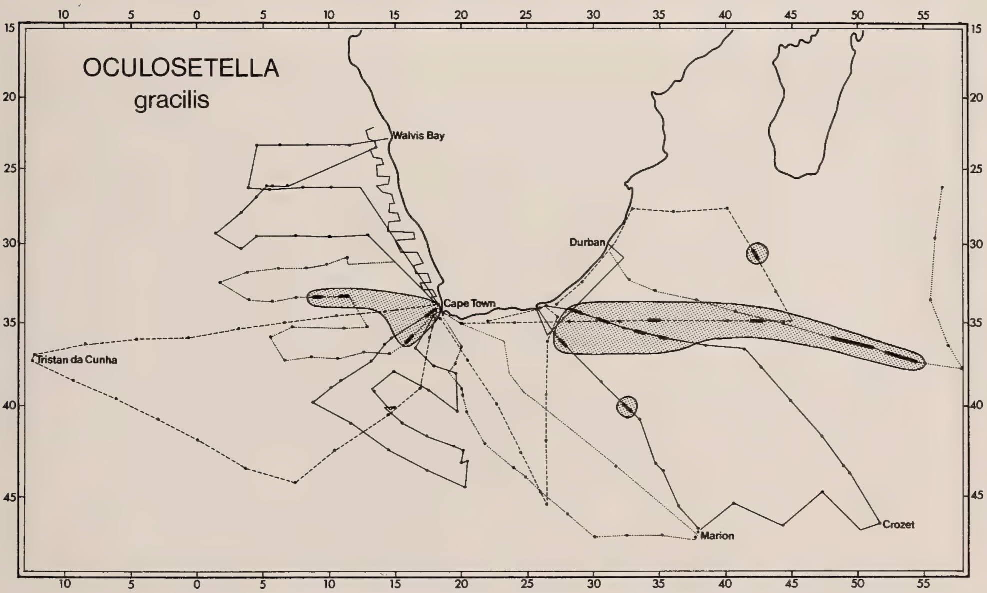
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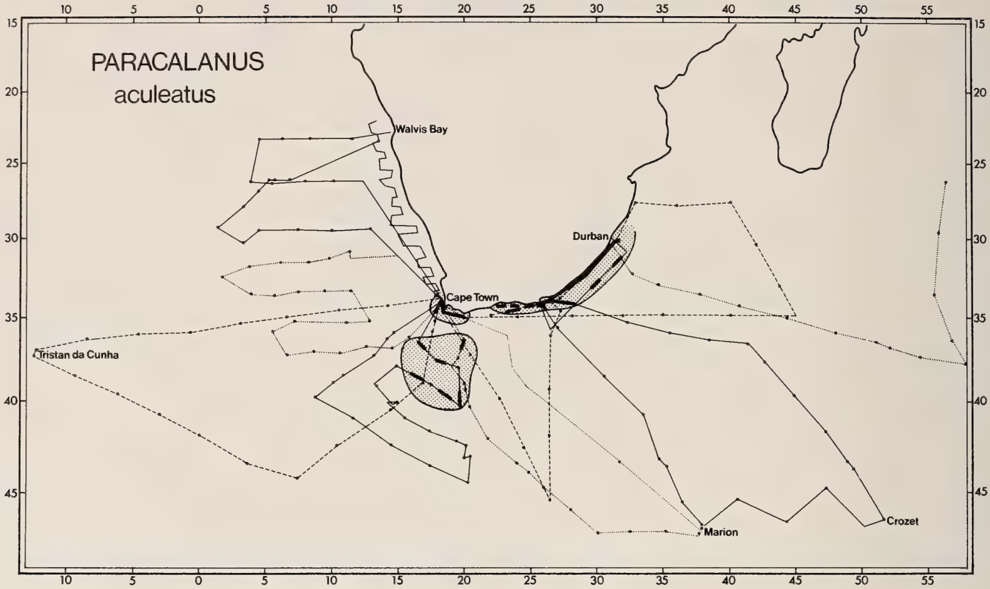
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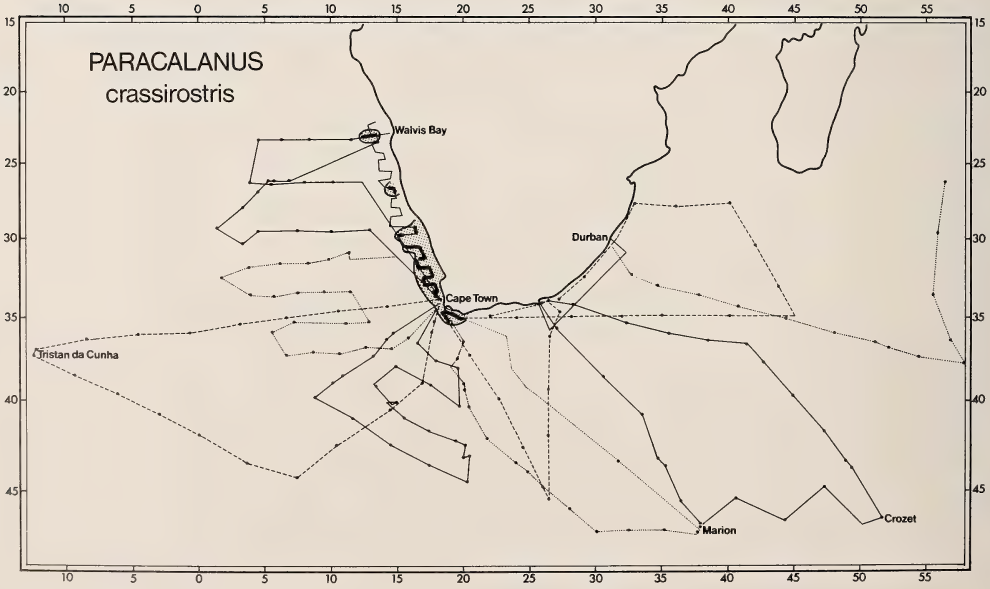
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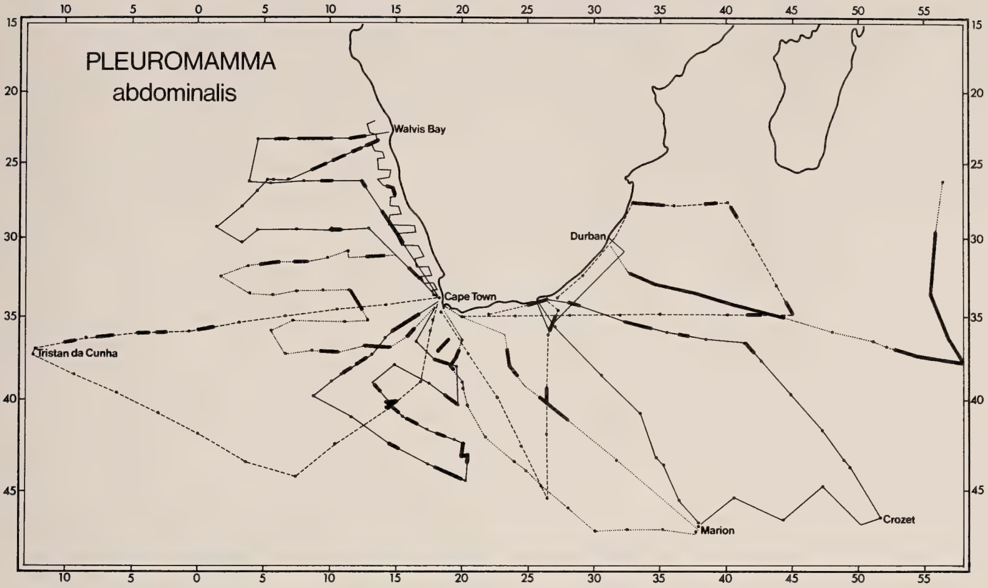
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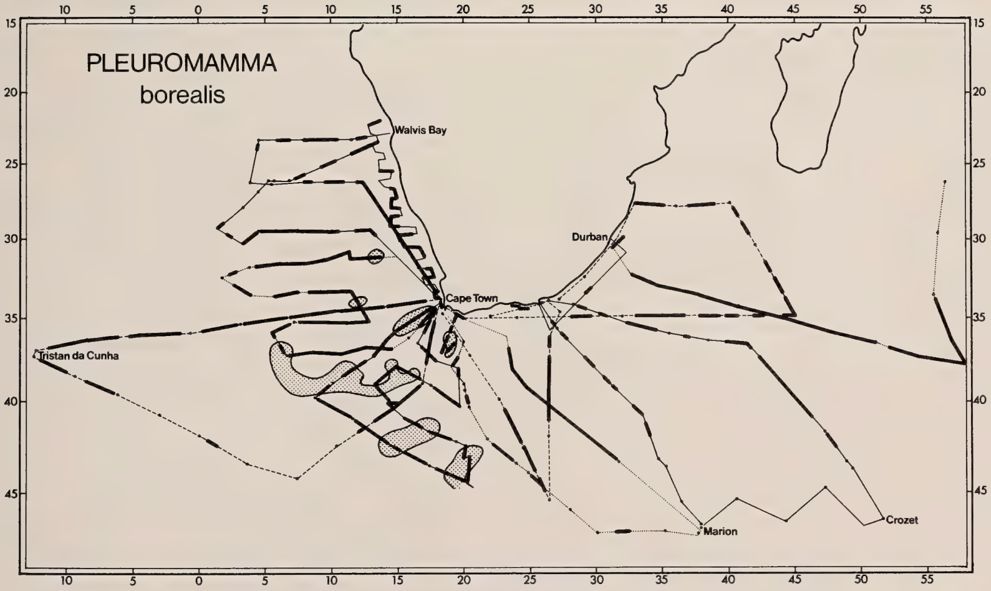
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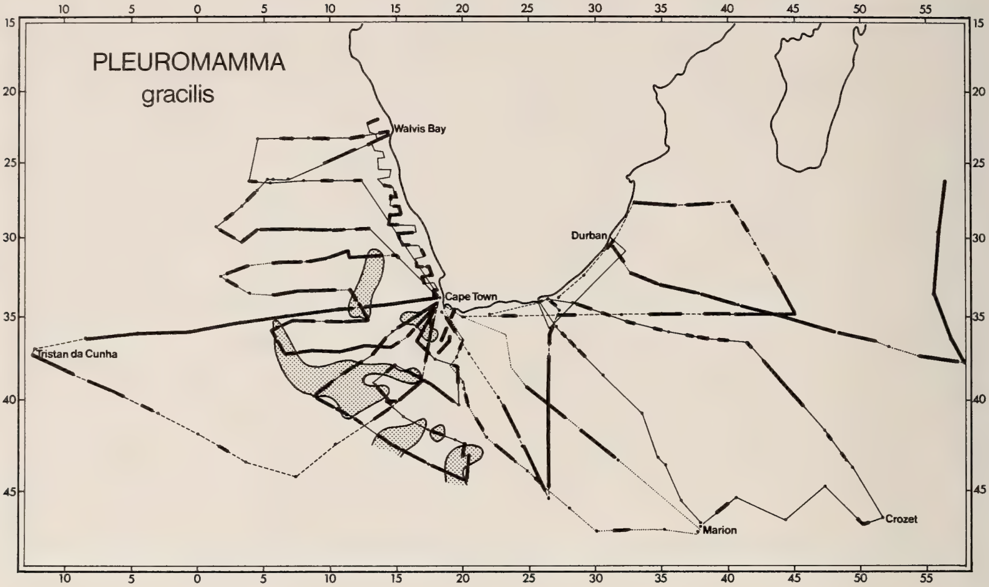
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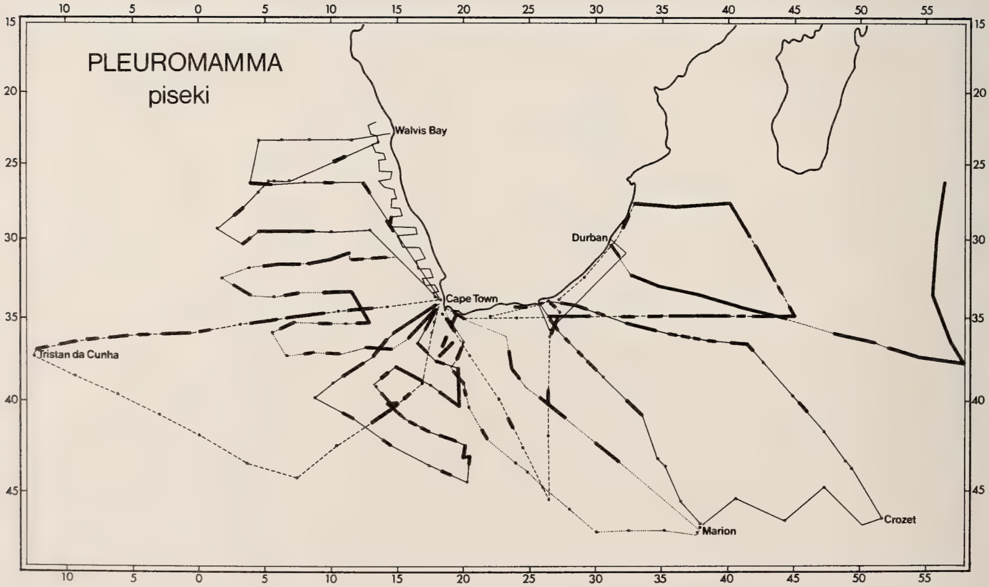
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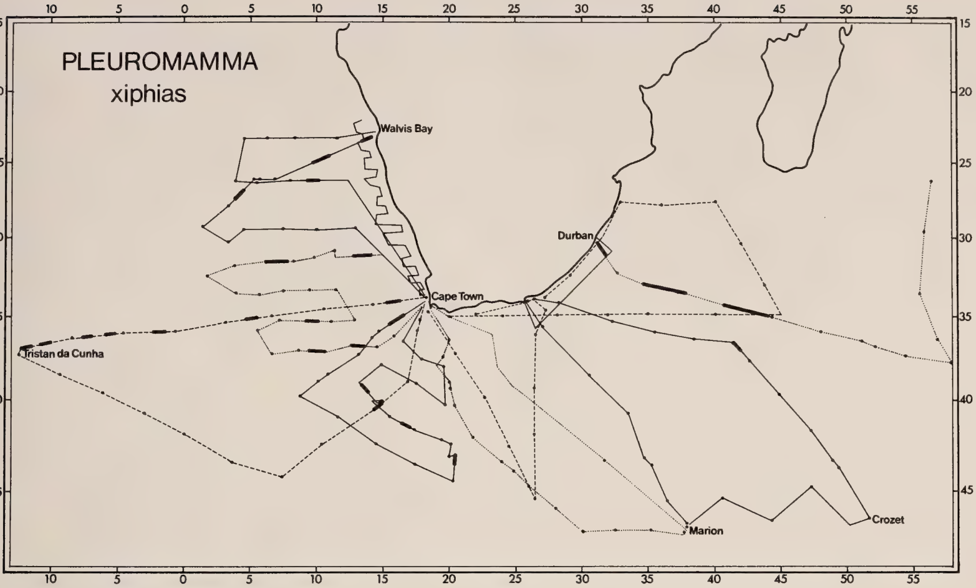
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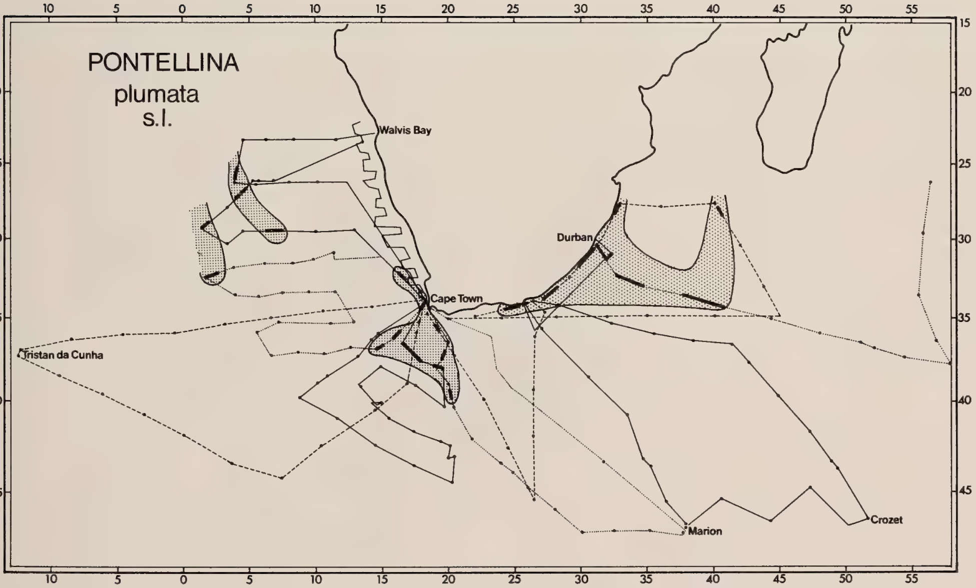
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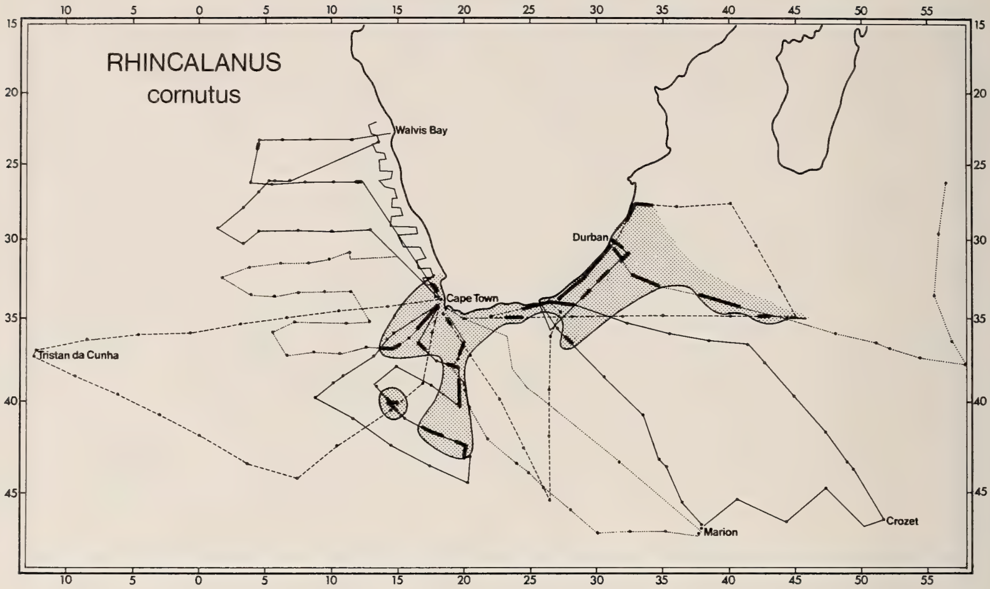
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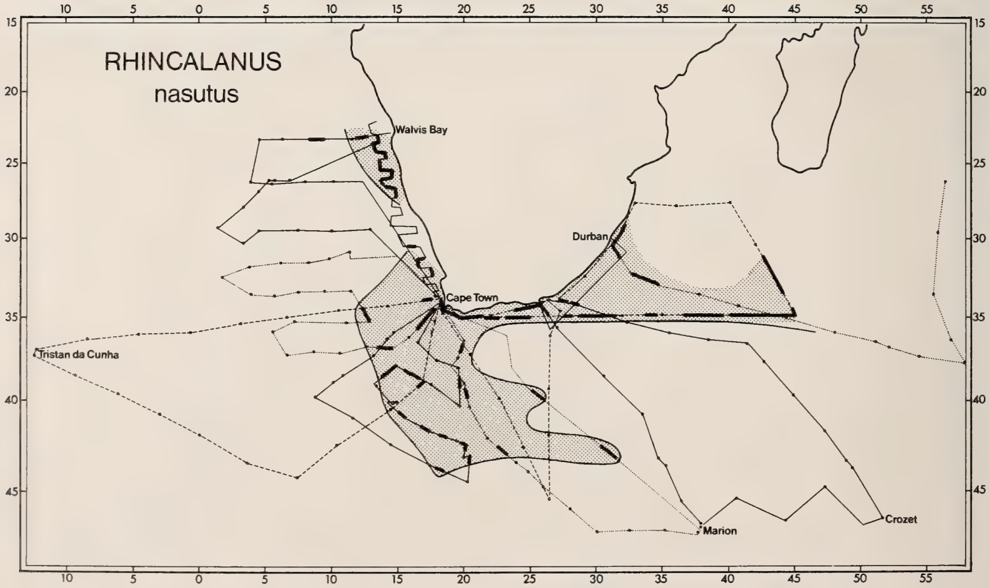
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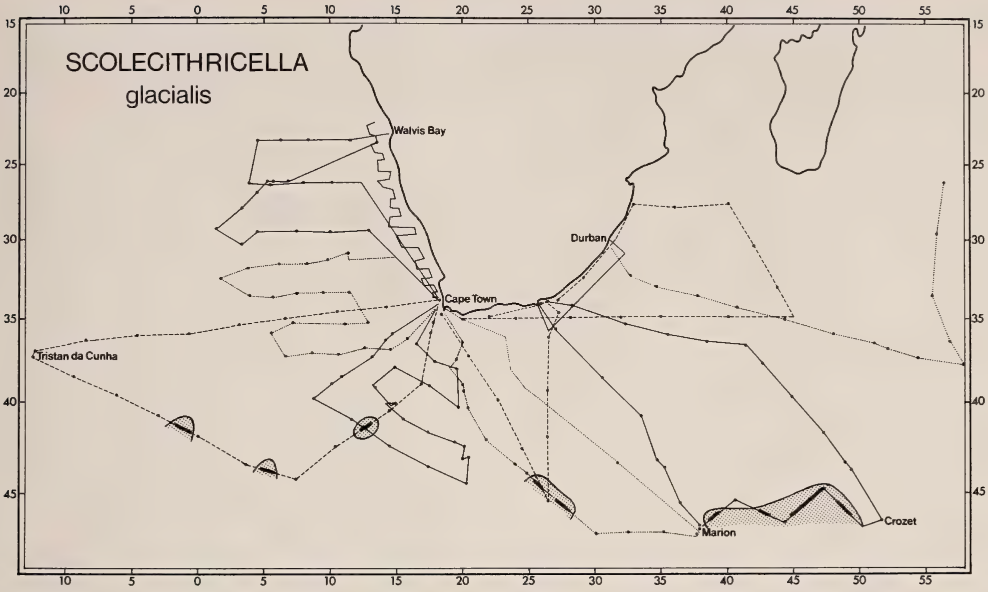
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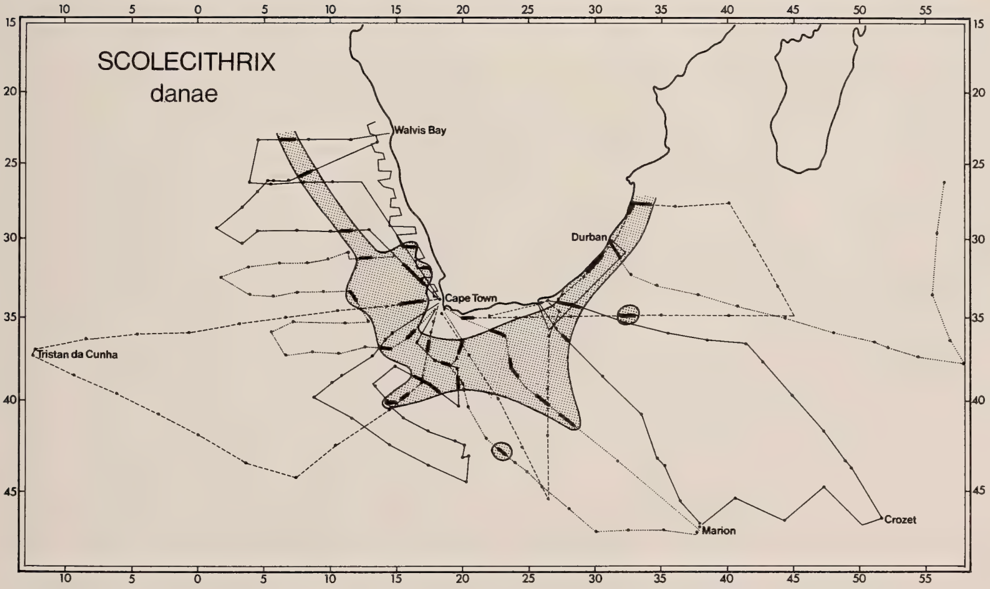
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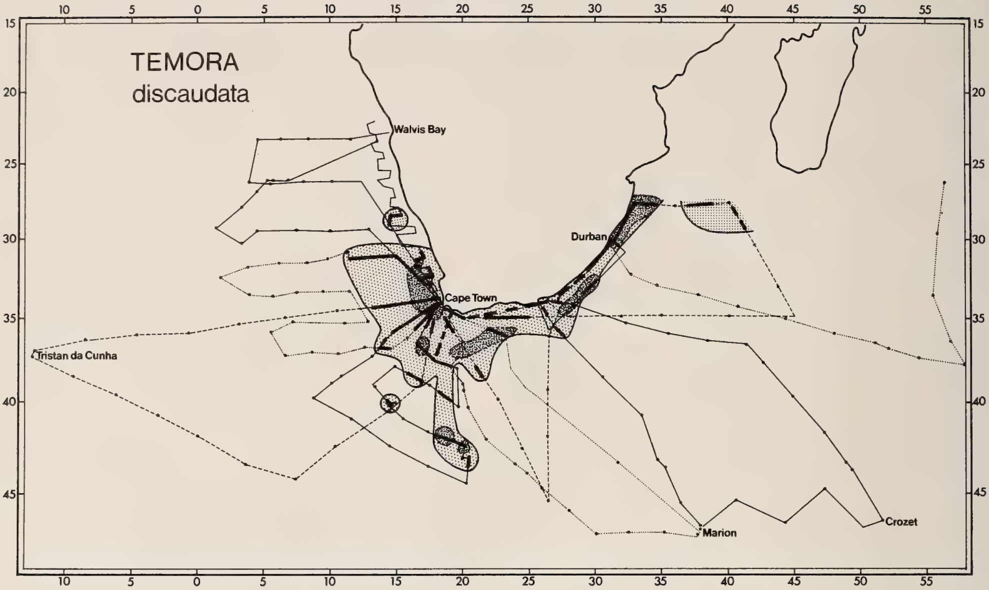
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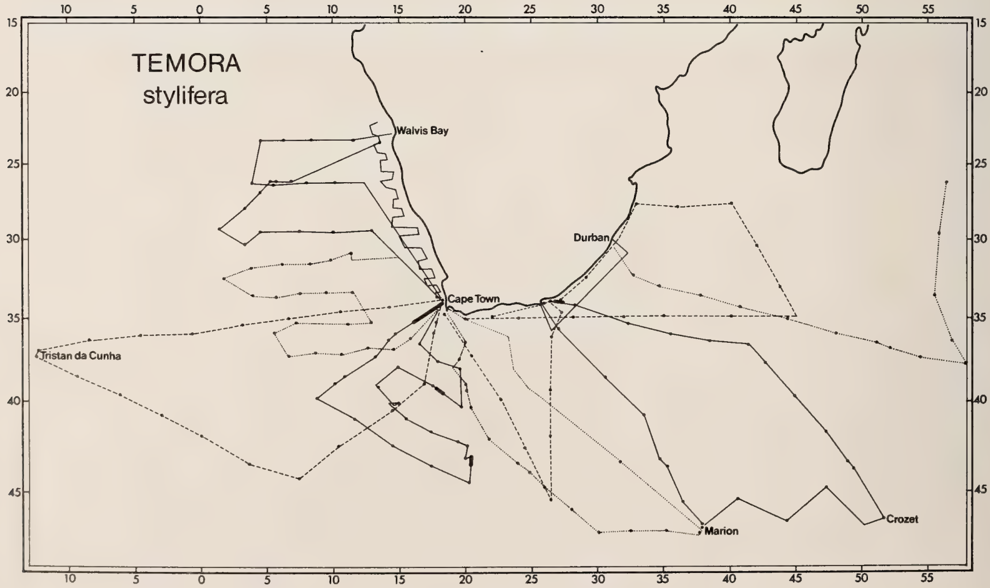
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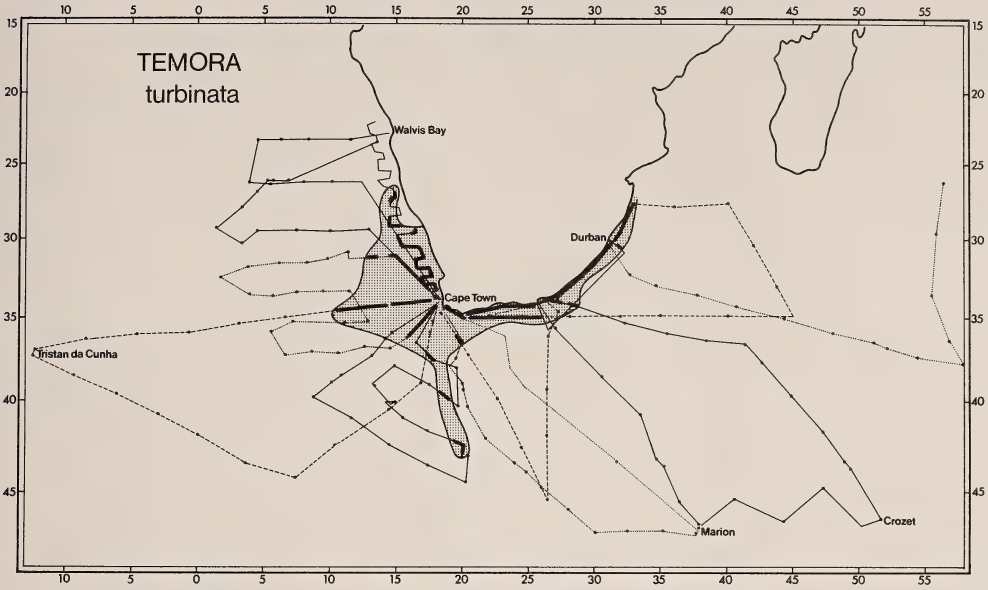
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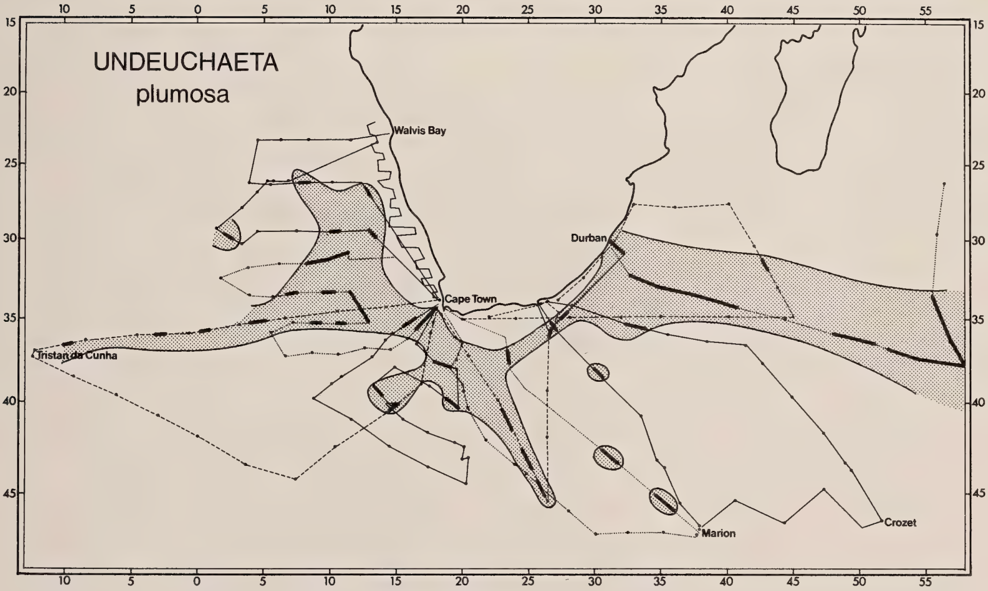
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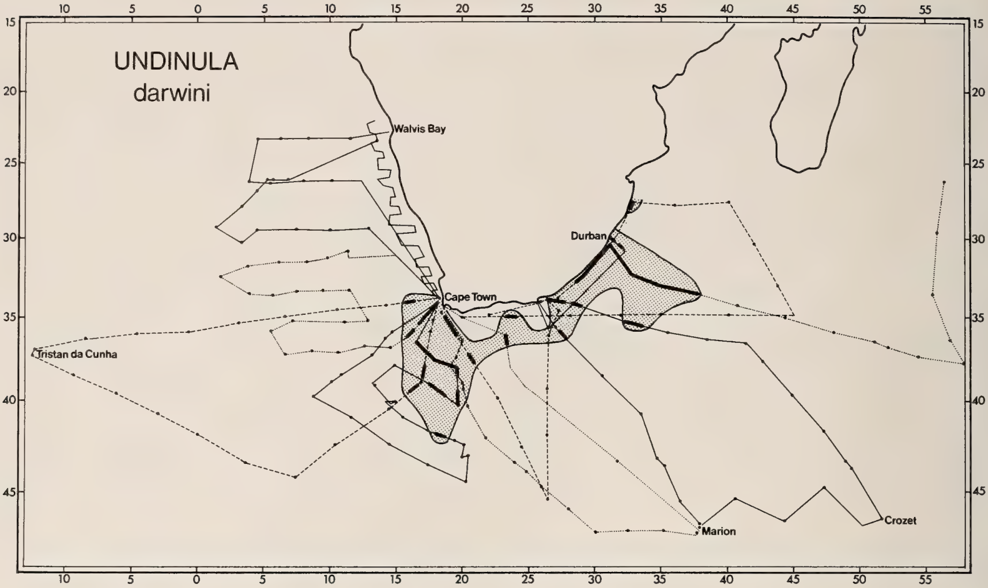
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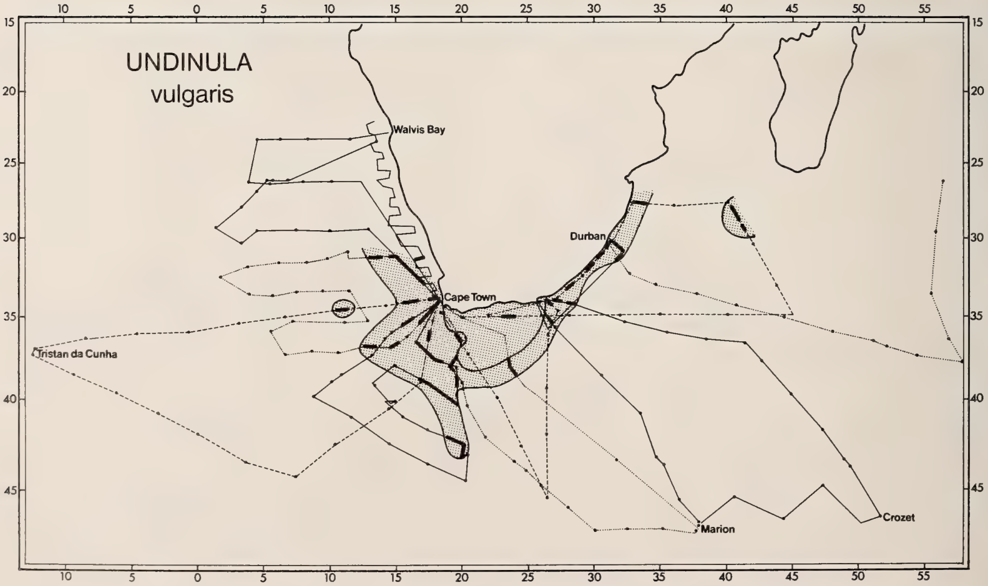
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ACKNOWLEDGEMENTS

Thanks are due to the numerous staff members of the Division of Sea Fisheries, Cape Town, who in between their various duties on board ship most kindly helped with the collection of the samples; to my wife, M. M. De Decker, who helped considerably with the processing of the samples; to Mr V. Branco and Miss E. L. McArdell who produced the artwork; to Miss B. A. White who typed the manuscript, and to Dr P. A. Hulley who read the report and offered valuable suggestions and criticism.

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6. SYSTEMATIC papers must conform to the *International code of zoological nomenclature* (particularly Articles 22 and 51).

Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family **Nuculanidae**

Nuculana (*Lembulus*) *bicuspidata* (Gould, 1845)

Figs 14–15A

Nucula (*Leda*) *bicuspidata* Gould, 1845: 37.
Leda plicifera A. Adams, 1856: 50.
Laeda bicuspidata Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).
Nucula largillierti Philippi, 1861: 87.
Leda bicuspidata: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:
comma separates author's name and year
semicolon separates more than one reference by the same author
full stop separates references by different authors
figures of plates are enclosed in parentheses to distinguish them from text-figures
dash, not comma, separates consecutive numbers

Synonymy arrangement according to chronology of bibliographic references, whereby the year is placed in front of each entry, and the synonym repeated in full for each entry, is not acceptable.

In describing new species, one specimen must be designated as the holotype; other specimens mentioned in the original description are to be designated paratypes; additional material not regarded as paratypes should be listed separately. The complete data (registration number, depository, description of specimen, locality, collector, date) of the holotype and paratypes must be recorded, e.g.:

Holotype

SAM–A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach Port Elizabeth (33°51′S 25°39′E), collected by A. Smith, 15 January 1973.

Note standard form of writing South African Museum registration numbers and date.

7. SPECIAL HOUSE RULES

Capital initial letters

(a) The Figures, Maps and Tables of the paper when referred to in the text
e.g. '. . . the Figure depicting *C. namacolus* . . .'; '. . . in *C. namacolus* (Fig. 10) . . .'

(b) The prefixes of prefixed surnames in all languages, when used in the text, if not preceded by initials or full names
e.g. Du Toit but A. L. du Toit; Von Huene but F. von Huene

(c) Scientific names, but not their vernacular derivatives
e.g. Therocephalia, but therocephalian

Punctuation should be loose, omitting all not strictly necessary

Reference to the author should be expressed in the third person

Roman numerals should be converted to arabic, except when forming part of the title of a book or article, such as
'Revision of the Crustacea. Part VIII. The Amphipoda.'

Specific name must not stand alone, but be preceded by the generic name or its abbreviation to initial capital letter, provided the same generic name is used consecutively.

Name of new genus or species is not to be included in the title: it should be included in the abstract, counter to Recommendation 23 of the Code, to meet the requirements of Biological Abstracts.

A. H. B. DE DECKER

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